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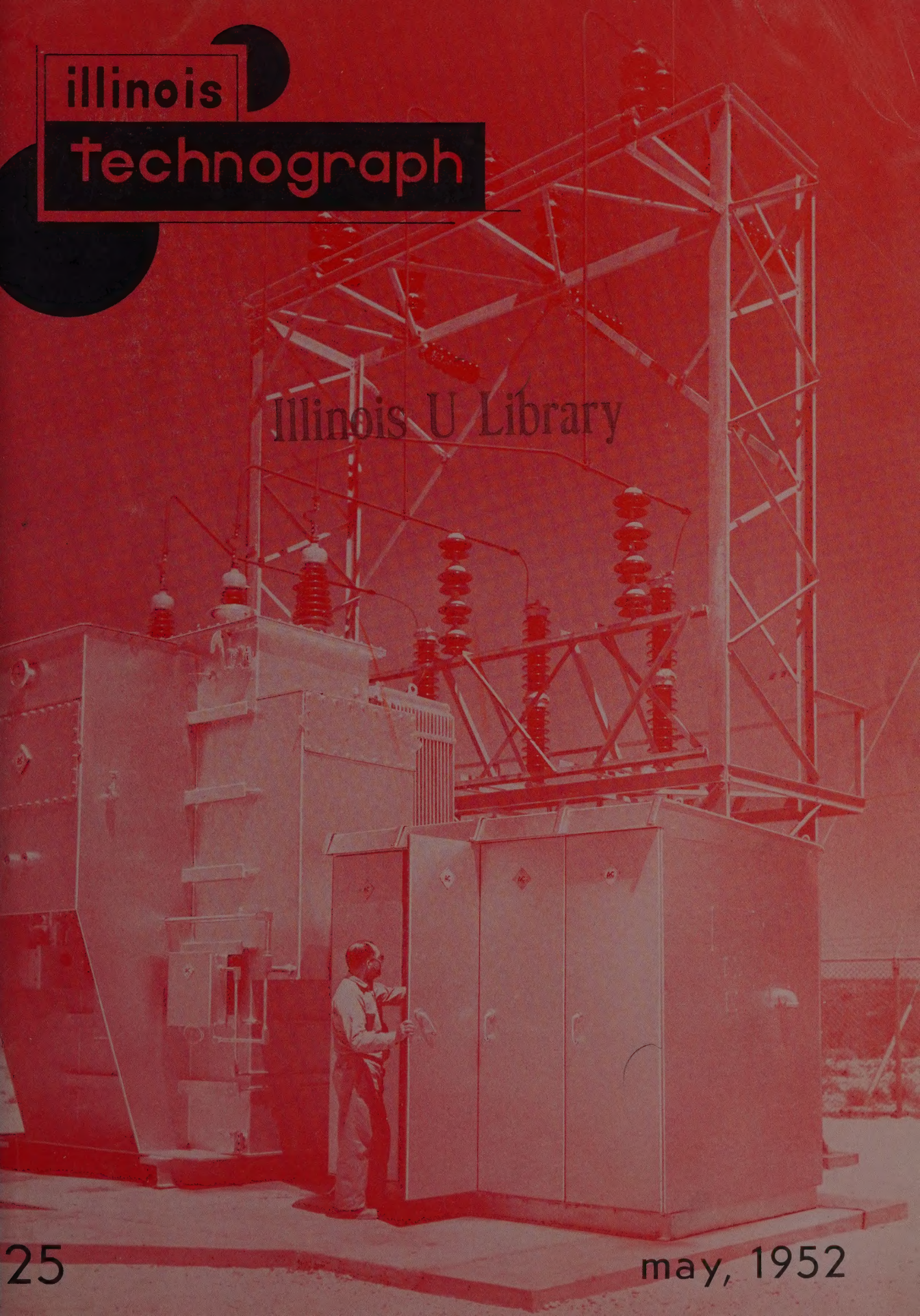

25

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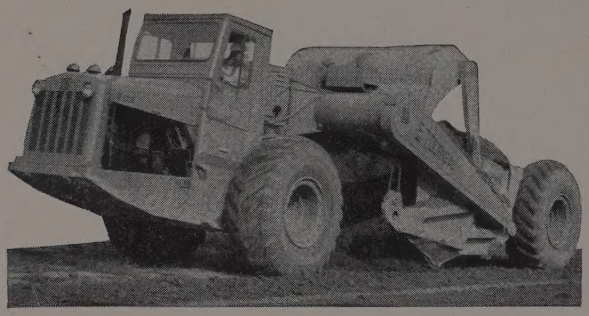
Another page for **YOUR BEARING NOTEBOOK**



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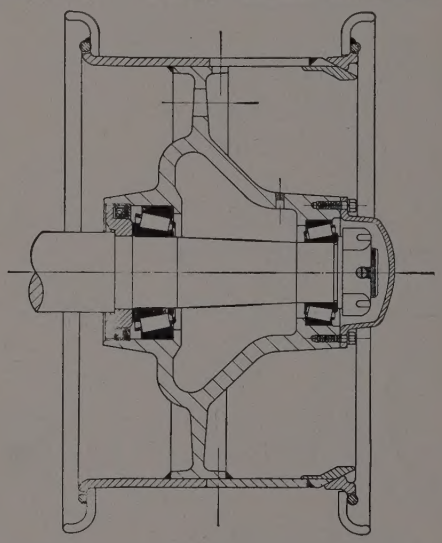

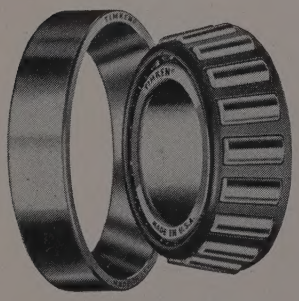

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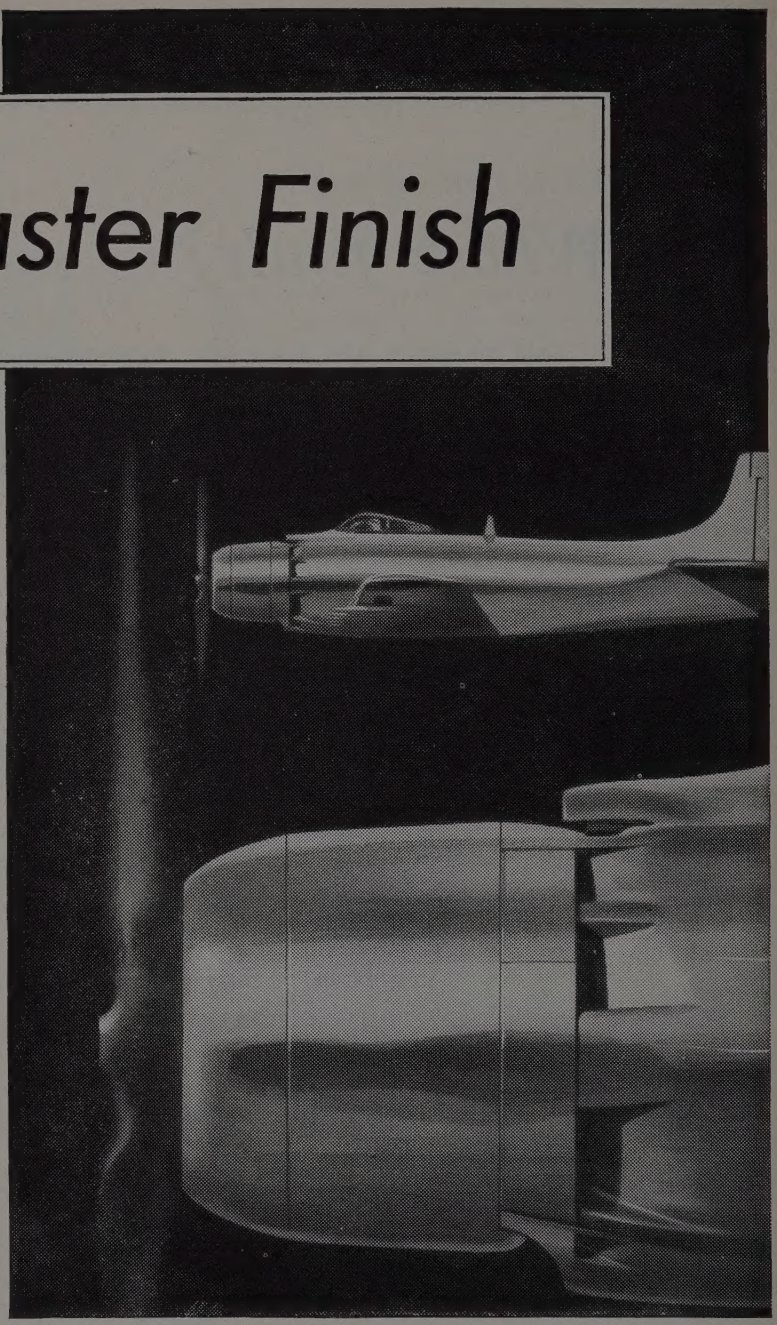
Whose fault?

Near the end of April every year, Ma-Wan-Da and Sachem select their new members. The ILLIO prints its pages of campus leaders. Yet, few, if any, of those honored are engineers. This year two engineers were campus leaders, and they held posts which are listed every year. Why are there so few engineers honored? Who is at fault?

Surely, you say, the people south of Green Street are responsible. Are they not the ones who control the selection? Certainly the president of the Engineering Council is a campus leader. Is he not the student head of one of the largest colleges in the University? I might stick out my neck and say, "Why not the editor and business manager of the TECHNOGRAPH?" The TECHNOGRAPH reaches all the high schools in the state. Neither the DAILY ILLINI nor the ILLIO helps to influence the high school student in a similar manner.

But all the blame can not be placed on the door-steps of our south campus neighbors. You, ENGINEERS, must carry your share of blame. More of you must become active, not only in engineering activities, but elsewhere. I know that you have come to Illinois to learn to be an engineer, but an engineer must be more than a calculating machine. An engineer must be human. More and more, industry is placing engineers in executive positions. In such a job, the engineer must be able to work with persons who are not engineers. You can learn that only by working with those who are not engineers. I do not advocate your quitting engineering activities. It is hard enough to get you to work on them now. I do advocate your getting to work on activities. Why is the engineer so often pictured as a grind who does nothing but eat and study (no sleep)? Because too often this is true of the engineering student. It need not be this way. Cut out your bull session once a week and join an activity. Only by overcoming the rest of the University by sheer numbers of students in activities can we ever be recognized by south campus. Do you want more engineers to be recognized for what they are worth? Then be worth something more than a machine. Get to work.—T.C.T.

No Faster Finish



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contents:

editorial ---- 5
merits of engineering graduates ---- 9
electrical engineering department ---- 10
camp rabideau ---- 12
navy pier ---- 13
considerations in a servo system ---- 14
co-op plan ---- 16
skimming industrial headlines ---- 20
introducing ---- 18
boneyard bilge ---- 26
technocracks ---- 36
magic slide rule ---- 48

our cover

An electrical engineer checks a 6,000-kva multi-circuit unit substation. Power distribution is a very important phase of the electrical engineer's work. Our featured engineer this issue, the EE has made life more comfortable for millions of Americans. It would be difficult to imagine life in these United States without the benefit of modern planned electrical living. We salute you, EE: your ingenuity and foresight have enabled engineered progress to exceed all bounds. (Cut courtesy of Allis-Chalmers ELECTRICAL REVIEW)

our frontispiece

Navy men manning an electrically controlled gun-director. On the sea as well as on land, the electrical engineer has applied his knowledge toward the ends of national defense. In electronics and communications the engineer has bridged the gap of space, darkness and weather. In his efforts directed toward improving the instruments of defense, the EE has discovered applications adapted to our everyday living thus widening the scope of our material comforts. (Cut courtesy General Electric Company)

Industry appraises . . .

Merits of Engineering Graduates

by J. L. Michaelson, General Electric Company

What are the characteristics that General Electric looks for in the engineering graduate? This question is often asked, and it is one to which there are, perhaps, many sincere but different answers given by General Electric men. A sales engineer in one of our district offices might be inclined to stress personality characteristics; a design engineer from the Turbine Divisions might emphasize technical analytical ability; a laboratory man would be sure to want keen observation and creative ability. All of these men would no doubt agree that the young engineer graduate should possess adequate training in fundamentals, but, upon further questioning, they might have difficulty agreeing on what the "fundamentals" are.

If General Electric men do not always seem to agree, then it is not surprising that other companies may appear to have different standards. A small electric motor manufacturer might want the new engineering graduate entering his employ to be a pretty good expert on the design of small electric motors. He might hope that a large part of the engineering curriculum dealt with small electric motor design, perhaps, to the complete exclusion of such subjects as advanced thermodynamics and electronic circuits. Naturally, such an engineering curriculum would not produce the "expert" needed by a turbine manufacturer or by a radio manufacturing business. Since there is no way to determine in advance what kind of engineering job the graduate will find himself in, it is necessary to have an engineering curriculum which will give the engineering student as broad a training as possible.

The engineering curriculum has been given a tremendous amount of study and thought by the country's best qualified men. Development of this curriculum never will be complete, of course, but today's engineering curriculum seems to pretty well fill today's needs.

I believe that the engineering student should put forth his very best efforts on all the subjects in this curriculum. There is a good reason for each subject. The student may not like some of them, but he should realize that these subjects are not put in to punish him, but are there for his development.

In applying his best efforts to all subjects, a student will whet his appetite for new knowledge; sharpen his wits and powers of observation; develop logical thinking; increase his store of knowledge, and develop a strong desire to accomplish something worth while. At the same time, he will learn how to cooperate with his fellow students and faculty alike; he will learn the importance of teamwork and develop an appreciation for the other fellow's point of view. He will learn the importance of serving his profession faithfully and discharging his obligations of citizenship with unselfishness.

What, specifically, are the characteristics the General Electric company is looking for in the engineering graduate? We are interested in the kind of job he has done at this business of going to college. The best way to judge a race horse, they say, is to determine how he has run in the past.

We are interested in whether the student has met his obligations, taken advantage of his opportunities and developed his concepts of morals and ethical conduct. Has he learned to think logically? Does he appreciate the other fellow's point of view? Does he have a strong urge to accomplish worth-while things? Is he alert? Is he of sound character? Does he have a desire to expand his knowledge? Is he creative? Is he willing to work hard? Is he a little bit humble toward the world? Is he versatile enough to be adaptable in any situation? These are the kinds of questions which run through a General Electric recruiter's mind, and as might be expected, different recruiters will give these characteristics slightly different weight, but, generally they will arrive at similar conclusions on a particular individual.

I have said very little about looking for an "expert" in any particular line. Our activities are so broad and diversified that we need all kinds of "experts," but we think the best way to get them is to train them ourselves. Therefore, we look to the engineering college for the basic engineering training. We have little interest in specialization at this stage of the engineer's development.

The young technical graduate enters the General Electric company through one of several technical training programs designed to bridge the gap between college and industry. It is through these programs that he learns about the company's many and diversified operations, and, thus, the details of the many opportunities available to him. He has an excellent opportunity to develop his ability in the field of his particular interest.

For those who have the desire and aptitude for sales engineering, we have a program designed to give them the kind of practical experience they will need, together with appropriate classroom work.

Similar arrangements are made for those interested and qualified in manufacturing engineering.

A creative engineering program is available to those with aptitude for creative work in engineering.

Our Advanced Engineering Program is nationally known for the quality of its graduates. The men who qualify for this program are given a well-rounded training in fundamentals, and they specialize in one of the several fields.

In addition to these formalized programs, there are many other educational opportunities available to the young engineer in General Electric. He is encouraged to continue his engineering education through these company programs.

Our engineers must do more than keep abreast of engineering knowledge; they must lead in their respective fields.

This $1,300,000 structure, dedicated in 1949, houses one of the finest and best-equipped electrical engineering schools in the country.

the Technograph features the . . .

Although the electrical engineering school is one of the youngest in the engineering college, it has grown more since its formation than perhaps any other department in the college.

As in most universities, the E.E. school here at Illinois had its beginnings as a division of the physics department. It was first made a separate school in 1895, when the University was under the administration of President Draper. It remained a separate school for just one year, and then was recombined with the physics department until 1898 when the two departments were again separated, this time for good.

At this time, the department shared the Mechanical and Electrical Engineering building, now called the E.E. Research Lab with the M.E. department. The University power plant was also located in that building. When the power plant was moved in 1911 to the Mathews avenue building, the resulting space was devoted to lecture rooms for the E.E. department.

In 1925, due to the great increase in enrollment in the new school, a complete dynamo lab was equipped, and in 1929, the T.&A.M. department moved to Talbot lab. This left the old T.&A.M. building for the use of the electricals. This building, which is now called the E.E. Annex, is located just across the Boneyard from the E.E. Research lab. The two buildings were connected with a hallway which bridges the Boneyard.

At this time, the combined E.E. buildings housed a dynamo lab, a radio lab, and a communications lab, plus lecture rooms and space for individual research. The lecture room seated 300 and was considered quite adequate.

Around 1928, the Bell Telephone system donated much equipment to the University, including an artificial line which simulated 200 *mi.* of open wire telephone line, a variable frequency oscillator, and several other items. Western Electric gave the department about 150 *ft.* of lead sheathed telephone cable containing 600 pairs of wires. It was installed between the E.E. Research lab and the E.E. Annex. Through a system of connections, the 600 pairs of wires could be connected in series, giving the equivalent of 12 *mi.* of twisted wire line.

The equipment owned by the department at this time was largely power equipment, but the communications lab contained several switchboards, the necessary cable, coils, and instruments for comprehensive study of telephone equipment and circuits.

The electronics and radio study division of the E.E. school was started in 1933-34. Much of the equipment was designed and built by students. The radio lab had been built before this, back in 1921. The University was granted a license by the FCC to broadcast on 360 meters, that is, a broadcast band frequency of 836 kilocycles. This station was the forerunner of WILL.

In 1933-34, another FCC license was given to W9YH, a short wave station broadcasting on 80 meters. This station is now operated by Synton, the amateur radio operators' organization on campus. It is interesting to note that, at this time, the department owned a 250-watt television transmitter. This was of the old scanning disk type and never went on the air. Demonstrations of TV transmission were given, however, at the E.E. shows, which were similar to engineering open house.

During these years, the illumination men were not standing still, either. In 1938, Professor J. O. Kraehenbuehl, present head of the illumination option, supervised the building of an icosohedron photometer, one of the few in the world. This was a twenty-sided room, ten feet in diameter, and was used for making light measurements.

The E.E. department continued to expand until it was decided that there just was not enough space to accommodate the large number of men desirous of entering this rapidly growing field. In February of 1947, construction began on the present E.E. building. The structure was built at a cost of $1,300,000 and an additional $300,000 was spent for equipment at that time. The building was dedicated in 1949. Since that time, many additional appropriations have been granted for equipment, until today, the electrical engineering school at the University of Illinois is one of the finest and best equipped in the country.

The new building's 80,000 square feet of floor area is divided into three floors and a penthouse. Most of the space is taken up by laboratories and offices. There are just 13 classrooms in the E.E. building. Most of these are located on the third floor along with the electronics, communications, radio, and ultra high frequency laboratories. The new network analyzer is also located on the second floor along with the network analyzer conference room. Laboratories and shops for the servicing of equipment, and instrument rooms are found on the second floor.

Electrical Engineering Department

by Don Sweet, e.e. '53

The first floor houses about half of the office space along with circuits and measurements laboratory. The E.E. lounge is in the northeast corner of this floor. Two lecture rooms with upholstered theatre type seats are located on this floor and are used for hour exams, club meetings, and seminars.

Downstairs, the largest area is used for the power lab. The power lab has a large plate glass window which allows visitors to see the entire lab. The lab has its own instrument room. Immediately in back of the power lab, the E.E. building shop is located. This is a complete machine shop used by building and machinery maintenance men.

The building has its own power substation, and a system of panel boards which permits the delivery of various AC and DC voltages to any lab in the building. For safety, the power lab has emergency push buttons located on every column. These buttons kill all the power in the lab with the exception of the lighting circuit.

The power lab here at the University is one of the largest labs of its kinds in any educational institution. It has been the policy of the department to furnish enough equipment in all of its labs so that an entire lab section may work on the same experiment at the same time. This means several sets of each kind of equipment. The department feels, however, that the expense of this duplication of equipment is warranted by the savings in instruction time. The lab instructors spend less time in explaining the experiments and have more time for giving individual help.

While less impressive perhaps, the electronics and communications labs are no less completely equipped. In the communications lab, transmission of intelligence along wires is studied. The lab contains several artificial lines simulating several miles of open-wire and twisted pair lines.

The radio lab contains all the necessary equipment for a comprehensive study of present-day radio circuits. Modern AM and FM receivers are laid out on large "breadboard" type layouts, permitting graphic demonstration of the functions of the various elements making up a modern radio receiver.

The penthouse of the E.E. building, added to the building after its completion, houses the antenna laboratory. Here measurements of radio wave field strength are made, and various antenna designs are studied.

The latest addition to the vast and expensive equipment in the E.E. building is the network analyzer. This apparatus, which fills an entire room, was begun in 1950 and was completed in April this year. The cost of the analyzer, about $50,000, was paid chiefly by three power companies.

The analyzer is a machine which is capable of solving 400 simultaneous equations. These equations must be set up in the form of electrical networks before they can be put into the machine. The answers can be read from meters at the control desks. Problems are usually worked on a per-unit basis, so the readings of the meters must be multiplied by some factor to give the desired answer.

The big use of the analyzer is in

(*continued on page* 32)

Left to right, Glenn M. Cate, Professor Max A. Faucett, and Professor Paul A. Egbert operate the "electric network analyzer" which is used to reproduce power networks and as an electric calculator.

. . . where the civil engineers learn surveying

by Warren Brandt, c.e. '54

A tourist from the Prairie State driving along one of Minnesota's scenic, lake-lined state roads might be somewhat surprised to see the above sign—a symbol of civilization in a region of wilderness. And his amazement would increase as he entered the grounds of Camp Rabideau, the University of Illinois Civil Engineers Surveying Camp.

The visitor would find a number of green painted buildings, kept in good repair, the evidence of a former CCC camp in the heart of the Chippewa National forest. Further examination would disclose barracks-type structures used for student housing. Camp offices and storerooms are in other buildings of a similar description. The entire camp has its own water supply and electricity is flickered in by the REA.

The civils have been coming to Camp Rabideau since 1946, when the University established this field laboratory for surveying and mapping instruction. Suitable sites were extremely difficult to find and this camp situated six miles south of Blackduck, a two-tavern town 35 miles northeast of Bemidji, the home of Paul Bunyan, was the answer to the search.

The student at Camp Rabideau occupies his daylight hours with field instruction in the course designated as C.E. 102. He becomes familiar with the tape, transit, level and plane table, the latter being sort of a drawing board mounted on a tripod.

The work with the tape takes the student over a good deal of the surrounding terrain, and sometimes when the pull on the tape exceeds the breaking point of the material, well, "Mac," Camp Rabideau's official repairman, has work to do (including the preparation of a bill)! Judicious handling of the tape can forego this possibility, however.

The transit and the level of course are the most coveted prizes and the student is probably more eager to learn their operations than to perform any other feat. Since he has probably seen the instruments in use he has a natural curiosity concerning their function and the average student easily becomes proficient in their handling.

Associated with the work with the transit are observations taken on Polaris, a star located somewhere in the heavens. This rather evasive orb holds a special charm for the engineer and it would seem that he would rather be viewing it than doing anything else. Naturally the observations on Polaris must be carried on at night as everyone knows the only way you can see this star in the daytime is from the bottom of a deep, dark, vertical mine shaft. Such an item is not available at the camp at present.

The student is introduced to mapping by making a map, a rather efficient way to say the least. He has the pleasure of working on Montgomery's field, a local character who blew his neighbor's head off (neither of them are around anymore), or maybe over by Jack Smith's place. Jack's the man who rents boats on Lake Rabideau. Or perhaps he would like to map those extensive wooded areas southwest of the camp. Beautiful country and the wildlife in there, why it makes you think you're with the Natural History Survey.

Mentioning the lakes seems a good time to tell about them. They are three in number, Rabideau, Carle and Benjamin. The latter has a very good reputation for swimming and fishing; besides it's only 300 feet away from the back door of Barracks 12.

The lakes occupy a short period of the student's time during which he sounds one of them, plotting his soundings on a chart he has drawn. When it's on land it's a map, when it's on water it's a chart. Confusing? He will find that Benjamin will sound around 150 feet. Pretty deep, eh?

But lest the visitor think that all the civils do at Rabideau is work, let's mention the other attractions. In the evening there is the baseball game. Now there is quite a rivalry between the different barracks, and the competition is pretty keen for the championship. Near the close of camp the two top teams are locked in conflict and the winner is cheered by all. At this point I would be derelict in my loyalty to the civils from Barracks 12 if I failed to note that they were 1951 champs.

Of course with the lakes so close, every student takes advantage of the opportunity to get in a few strokes. The water is cold but after a hot day in the field, it's pretty refreshing. Occasionally someone taking a measurement too near the shore will take an unannounced dip, but again a word to the wise is sufficient.

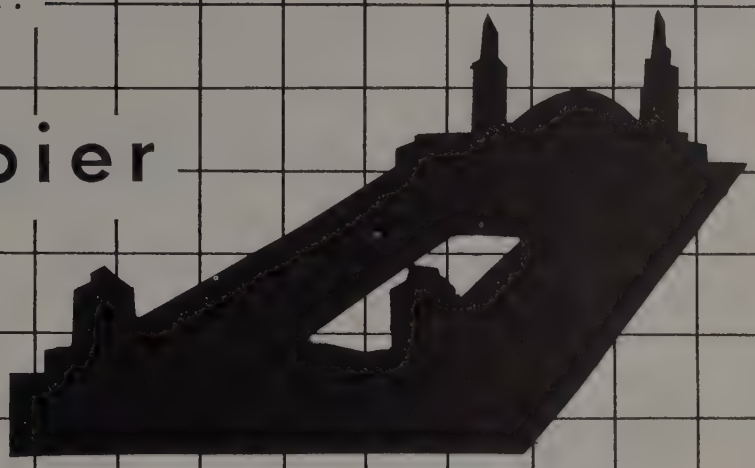
Movies have given considerable entertainment for the students and they are offered several times a week in a theatre seating 100. Also in this building is a library which attracts the bibliophile. For obvious reasons technical books are *not* available.

The features for which the student is especially attracted to Camp Rabideau are its wonderful climate and its unique scenery. Of course Minnesota has many such areas as that around the

(*continued on page* 34)

— *the university of illinois at . . .* —

navy pier



by Melvin H. Beckman, arch.e. '55

PIER IN THE PUDDLE

On March twentieth and twenty-seventh, the physics club held two meetings designed to familiarize its members with the development, operation, and uses of one of the more recent additions to the Chicago Medical Branch of the University of Illinois, its betatron. These two meetings consisted of a lecture on the machine by a member of the faculty, followed by a field trip to the Medical Center to see it in operation.

The idea for the betatron was originated in Germany about 25 years ago, but was not put into practical use until 1941 at the University of Illinois in Urbana. Essentially it consists of a high voltage transformer whose secondary coil has been replaced by an evacuated doughnut shaped tube made out of a ceramic material. The electrons are introduced into this tube by means of a heated filament. The magnetic field set up by the primary coil then accelerates them in a circular orbit to a speed they would attain when falling through a potential of twenty million volts.

In order to utilize these electrons it is necessary to remove them from the tube. This is accomplished by passing them through a laminated iron magnetic shield which will temporarily interrupt the magnetic flux set up by the primary coil. This will allow the electrons to escape their circular orbit and pass through a thin metal window in the ceramic tube. X-rays which contain more energy than the ordinary kind are produced by placing a metal target in the electron orbit.

The X-rays are used in the treatment of cancer. The electron beam can be used in the cancer treatment or in nuclear research.

The tour through the betatron laboratory consisted of the inspection of several different rooms which contain equipment used in connection with the betatron. There is a well equipped machine and electronic shop where auxiliary apparatus can be made when the need arises. Next to this is a storage room where instruments that are not in use are kept.

The area containing the betatron is divided into two parts separated by a lead lined wall. One side contains all the various electronic apparatus which is used in the operation of the machine and on the other side is the machine itself. It is a huge piece of equipment weighing about eight tons and is in the shape of a six-foot cube. When in operation the betatron gives off a high pitched whine which is caused by the magnetic flux being set up in the primary coil. Directly behind this room there are the power transformers. Here line voltage of a 220 volt potential is stepped up to about a 16,000 volt potential and its 60 cycle frequency is changed to 180 cycles.

During our stay at the laboratory we were very fortunate in having one of the members of the staff, Mr. Walter Henderson, as our guide. His explanations of the various pieces of equipment helped make our visit a most pleasant and informative one.

AIEE

On Tuesday, April 29, the American Institute of Electrical Engineers will go on a field trip to the Commonwealth Edison Company to inspect their network analyzer. This is a device which is used to determine anything wrong within the network.

The American Institute of Electrical Engineers will hold its annual election of officers during its May 13 meeting.

ENGINEERING COUNCIL

After a great deal of discussion, it was finally decided to hold a smoker on May 27 in the third floor lounge, from 2 o'clock until 5 o'clock in the afternoon. It is expected that there will be an abundance of FREE cigarettes and cookies for consumption by fortunate Pierites attending.

PERSHING RIFLES

The National Society of Pershing Rifles, Co. F, 3rd Regiment of the University of Illinois has started its new semester.

The elections which are held at the end of every semester resulted in James Trail being elected to the office of Captain Pershing Rifles. Other men being elected were: Emil Diewald, 1st Lt. P/R., Jim Holste, Lt. P/R., Carlos Bumzaham Lt. P/R., Jack Kleeman, Stg. P/R.

During the Fall semester of 1951-52 the commanding officer of the society was Capt. P/R Harry Hellmuth. I am sure that everyone will agree with me, that he is, and was one of the best officers P/R has ever known and an out-

(*continued on page* 34)

a discussion of the physical significance of stability . . .

Consideration

Every year, the student branch of the AIEE sponsors a technical papers competition. This year's district winner in the undergraduate division was Alfred H. Donahoe. The editors hope that by publishing Al's prize-winning paper future aspirants will gain some insight into the writing of a technical paper.

This paper discusses the classical solution of the characteristic servo differential equation and the physical significance of the various possible root forms. Two methods, the Routh criterion and conformal mapping, are presented as devices for determining the existence of unstable roots without solving the characteristic equation.

In most of the physical situations involved in feedback control systems, a satisfactory degree of accuracy is obtained if the system is described with a set of simultaneous linear differential equations with constant coefficients. For this reason most of the development in the field of servo system analysis has dealt with this situation, that is with the linear case. There have been two avenues of approach to the problem. In the early literature, investigations were primarily concerned with a study of the transient behavior of the system and the resulting effects upon system stability or instability. More recently there has been a recognition of the similarity between the problems of system analysis and those encountered in the field of feedback amplifier analysis. This has resulted in an increasing tendency to use the steady state frequency response method of analysis, making use of the highly developed theory of feedback amplifiers.

However, both the steady state method and the various operational methods devised for the transient method have a disadvantage that is especially serious for a person just entering the field. Both steady state analysis and the operational methods of transient analysis greatly facilitate the determination of system characteristics, but in the process some of the physical significance of the various mathematical operations becomes obscured. It is for this reason that the author has returned to the consideration of the transient behavior as shown by the classical method of solution of the characteristic differential equations in order to gain an insight into the physical meaning of the mathematical examinations for instability.

Since a servo system can be satisfactorily described by a set of simultaneous linear differential equations with constant coefficients, it is theoretically possible to represent the system by a single equation in one dependent variable which will have the same mathematical

n a Servo System

by Alfred Donahoe, e.e. '52

characteristics as the set. That is, it will also be a linear differential equation with constant coefficients of the form shown below.

$$1.\ \frac{d^nx}{dt^n} + A_1\frac{d^{n-1}x}{dt^{n-1}} + A_2\frac{d^{n-2}x}{dt^{n-2}} + \ldots$$
$$\ldots + A_{n-1}\frac{dx}{dt} + A_nx = F(t)$$

The complete solution of such an equation will completely describe the servo system response to any form of input function, F(t). Such a solution will be composed of two parts called the complementary function and the particular integral. The complementary function, when substituted into the equation as the dependent variable, has the property of causing the left hand side of the equation to become identically zero. The particular integral will be such that, when substituted as the dependent variable, it will cause the left hand side to become identically equal to F(t). It has been shown that the particular integral is a description of the steady state response of the system. That is, the condition that will be assumed when a infinite time has elapsed after the introduction of the input function. The present theory of steady state circuit analysis is based on this property. The complementary function has been found to describe the transient conditions that will arise during the period required for the system to again assume a state of equilibrium after the application of the input function.

Since the complementary function, when substituted into the equation, will reduce the left hand side to zero, it can be seen that this function will be a solution of the abridged differential equation obtained by setting F(t) equal to zero that is

$$2.\ \frac{d^nx}{dt^n} + A_1\frac{d^{n-1}x}{dt^{n-1}} + A_2\frac{d^{n-2}x}{dt^{n-2}} + \ldots$$
$$\ldots + A_{n-1}\frac{dx}{dt} + A_nx = 0$$

From this it will be noticed that the complementary function and hence the transient characteristics of the system will be independent of the type of input function employed. The solution of this abridged equation must fulfill the requirement that the sum of the function and its first n derivatives, when multiplied by the constant coefficients of the equation, will be zero. This means that the complementary function must be such that the function and all of its n derivatives will have the same variation with respect to time. The only known function that has this property is the exponential function. Then if a complementary function of the form

$$3.\ x = Be^{at}$$

is assumed and substituted into the abridged equation, the result will be

$$4.\ [a^n + A_1a^{n-1} + A_2a^{n-2} + \ldots$$
$$\ldots\ A_{n-1}a + A_n]\ Be^{at} = 0$$

which is the product of three factors, the assumed B, the exponential e^{at}, and the polynomal in a. If either the constant B or the exponential e^{at} are equal to zero, the above expression will be zero, but both of these possibilities are trite solutions. The third possibility is for a to assume a value that will cause the polynomial to become identically zero.

From the theory of equations it is known that a polynomial of the nth degree will have (ignoring any possibility of multiplicity) n roots. There will be n values of a that will cause the polynomial to become zero. There are three possible forms the roots of this polynomial might assume: pure real, pure imaginary, or complex. Since for a physical system the coefficients $A_1, A_2, \ldots A_n$ will all be real numbers, the imaginary, and complex roots will always appear in conjugate pairs. In general, then, the complementary function will take the form,

$$5.\ x = B_1e^{a_1t} + B_2e^{a_2t} + \ldots \quad \ldots + B_ne^{a_nt}$$

and the number of arbitrary constants B will be equal to the order of the abridged equation. If the equation has m equal roots (root of multiplicity m), the function will assume the form

$$6.\ x = (B_1 + B_2t + \ldots \quad \ldots + B_mt^{m-1})\,e^{a_1t}$$
$$+ B_{m+1}e^{a_2t} + \ldots \quad \ldots + B_ne^{a_{(n-m)}t}$$

Further if a pair of complex roots of the form $a_1 = \alpha + j\beta$ and $a_2 = \alpha - j\beta$ occur, the following transformation will more clearly illustrate their physical significance

$$B_1e^{(\alpha+j\beta)t} + B_2e^{(\alpha-j\beta)t}$$
$$= e^{\alpha t}(B_1e^{j\beta t} + B_2e^{-j\beta t})$$
$$= e^{\alpha t}[B_1(\cos\beta t + j\sin\beta t) + B_2(\cos\beta t - j\sin\beta t)]$$
$$= e^{\alpha t}(C_1\cos\beta t + C_2\sin\beta t)$$

For m pairs of equal complex roots the corresponding

(*continued on page 22*)

an experiment in learning . . .

THE CO-OP PLAN

by Bob Schrader, ch.e. '54

To students at any of twenty-odd universities the idea of an article on engineering cooperative schools may seem to be of little interest. "What's so unusual about a cooperative school," these students may say. "Our school has been co-oping for a third of a century, it's an engineering tradition." All this may be true, but to many students here at Illinois the idea of a co-op school is something new. This article will attempt to give these students an idea of what co-oping is all about. As examples of cooperative schools, we shall choose Cornell, Northwestern, Marquette, and Cincinnatti.

Cornell university sandwiches cooperative work in during summer vacations. Engineering is a five-year curriculum at Cornell, so the students begin work in industry in the summer following their sophomore year. This work is not required; it is purely voluntary on the part of the student. Also the student must be approved both by the industry in question and by the university.

The engineering curricula at Northwestern cover a five-year period and include eighteen months of practical work experience. The school year at Northwestern is divided into four quarters, counting summer school as one of the quarters. Students spend their freshman year and the first two quarters of their sophomore year entirely in classes. The summer between the freshman and sophomore years is a vacation.

The sophomore class is divided into two sections at the end of the second quarter. The first section of students begins work in industry. The second section remains in school and completes the full sophomore year. At the end of the spring quarter the two sections exchange places, with the students in section I leaving their industrial jobs and returning to school, and the students in section II beginning their industrial work program. This quarterly alternation between classes and work experience continues until the second quarter of the fifth or senior year. Both sections of students are in school during the last quarter prior to graduation. This setup is diagrammed for you in Fig. 1 on the opposite page.

Ordinarily students work in pairs to provide continuous coverage of one cooperative job throughout the year. While one member of the team is working, his alternate is in class. During his five years a student will complete twelve quarters in school and six quarters in industry.

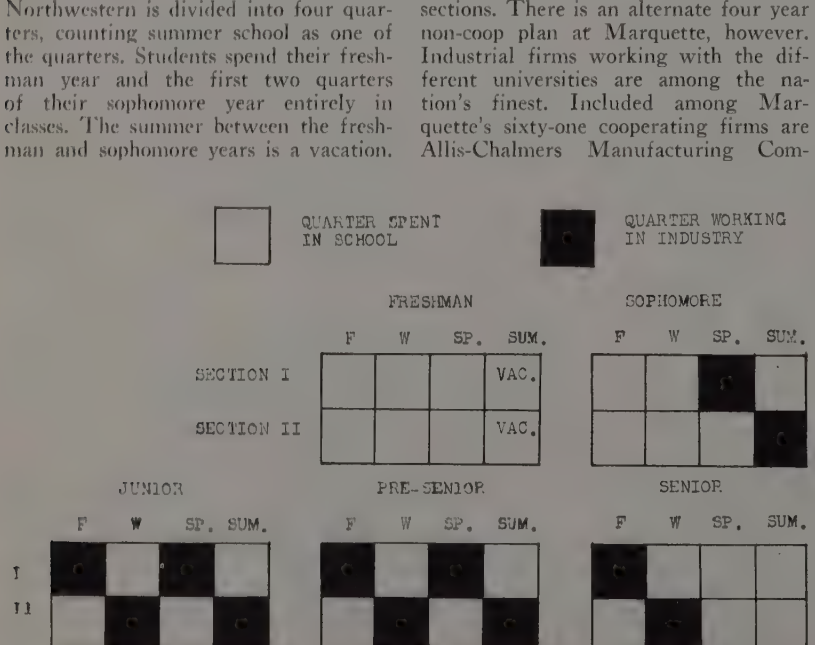
Marquette's plan is very similar to the one at Northwestern, with the school year being divided into quarters, and the engineering student body into sections. There is an alternate four year non-coop plan at Marquette, however. Industrial firms working with the different universities are among the nation's finest. Included among Marquette's sixty-one cooperating firms are Allis-Chalmers Manufacturing Company, the Chicago, Milwaukee, St. Paul and Pacific railroad, General Electric, International Harvester, and Westinghouse Electric.

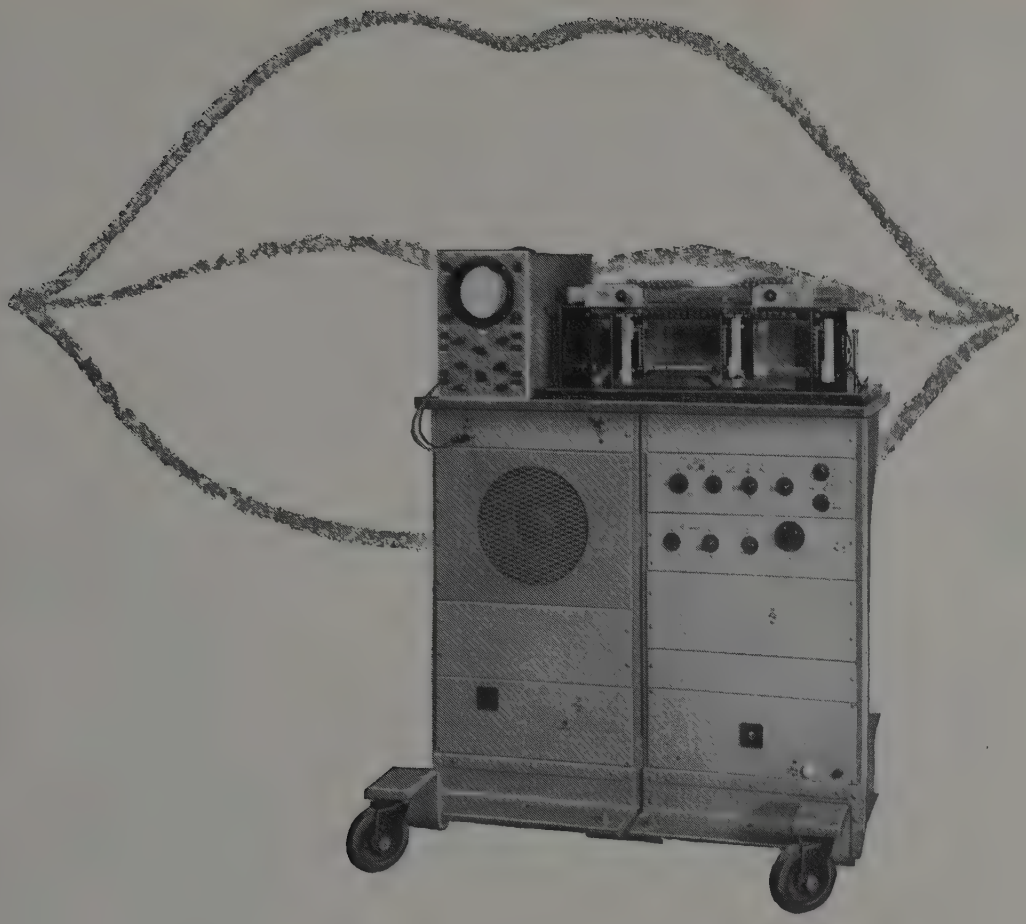
The cooperative course at the University of Cincinnati is of five year's duration, with a one-month vacation each year. The school year is divided into six terms of approximately eight weeks. Freshman students are required to attend school full time until the beginning of their fifth term. They then enter the cooperative program and continue on that basis until the second half of their senior year, when they return to school for full time attendance until graduation. The students are divided into two groups which alternate at the University and on the job every eight weeks. The satisfactory completion of eleven work periods is necessary to secure the Certificate for Cooperative experience.

The history of co-oping at Cincinnati is of especial interest, since that university is one of the pioneers in the field. Around the tur nof the century "Herman Schneider, a young college instructor at Lehigh university proposed a simple and direct plan for bringing industry and education together. He believed that engineering students should be given both practical and theoretical training through alternate periods at college and at practical work. These periods, equal in length, would be comparable also in educational value, since each would represent a progressive sequence from the elementary to the more advanced phases of study and experince. The sequences would be planned to emphasize the inter-relations between the theoretical and practical aspects of engineering training.

Though direct contact with the processes and equipment of industry in actual operation, the student-worker would have the benefit of a complete and up to date laboratory of applied science, while industry would have the services of an alert, young employe trained under practical conditions. During his work period, the student would receive pay at the standard rate and would otherwise have the status of a regular employe. Upon graduation from college, assuming that he made good and found the work congenial, he wou'

(*continued on page* 40)





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by Herb Gross, e.e. '55, Oliver Smith, m.e. '54
and Duane Loofbourrow, gen.e. '53

JOHN JOMBOCK

During the last great world conflict the Army of the United States realized the need for preliminary specialized training among its service men. As a result, it initiated a system whereby men, too young for the draft but graduated from high school, were sent to a college at the government's expense to receive basic engineering courses. Entitled "Army Specialized Training Reserve Program," it required that students pass an examination to make themselves eligible. This course provided

JOHN JOMBOCK

John Jombock with his initial engineering training and enabled him to get a valuable foothold in engineering before going into the service.

Born in Virden, Illinois, John attended both grammar and high school there, and upon completion of his secondary education he took the course offered by the ASTRP, mentioned above. When attaining the age of eligibility for the draft he was placed in the infantry in spite of the fact that he had specialized training. Jombock was transferred to the paratroopers when he completed his basic training and terminated his service in that branch.

After his discharge John had an aspiration of becoming an architect, so he enrolled at the Washington university in St. Louis. After completing two and one half years in architectural design, he discovered that he had interests in other fields of engineering. This was brought on in part by the summer work thata John did with the State of Illinois Division of Highways. He was employed in varied fields of work pertaining to inspection, surveying and construction during his summer vacation periods and thereupon became interested in civil engineering work.

In 1950 John transferred to the University of Illinois and began work in the hydraulic option of civil engineering. Finding structural option more attractive, he soon directed his interests in that sense. Structural option, by the way, deals primarily with the design of bridges and building frames.

Showing outstanding scholastic ability, John Jombock was elected to Chi Epsilon, Tau Beta Pi, and Sigma Tau, all honorary fraternities. As if this were not enough, this busy fellow went on to become the president of Chi Epsilon which is the civil engineer's own honorary. Also a member of ASCE, John is that organization's delegate to the Engineering Council. Much of the success of the recent St. Pat's ball can be attributed to John, because this friendly gentleman was the chairman of the committee in charge of the affair.

John has not made any definite decisions regarding post-graduate work, but he is carefully considering all of the offers made to him by employers during this, his last semester of undergraduate work.

PHILIP KENTON TRIMBLE

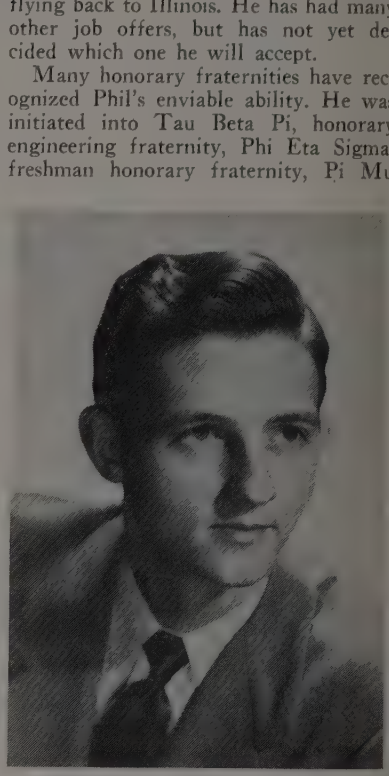
Philip Kenton Trimble, better known as Phil, is a senior in electrical engineering here at the University of Illinois. He hails from St. Joseph, Illinois, and had his prep training at the St. Joseph Community high school.

Phil is a member of Alpha Chi Rho social fraternity, but he has only lived in the house one of his eight semesters. The other semesters he has commuted between Urbana and his hometown.

While maintaining an almost perfect scholarship record at Illinois, Phil has also been very active in extra-curricular activities. He is Engineering Council Representative for the AIEE-IRE and serves as Treasurer of the Council. He must enjoy working with money (who doesn't) as he is also treasurer of the University Men's Glee Club. He got his musical training from trombone lessons and put them to good use playing in the University's Second Regimental band for four semesters.

Phil had a nice experience last month when he went with the Glee Club to sing with the Chicago Symphony Orchestra. From Chicago, he flew up to Detroit, Michigan, at the expense of General Motors and spent a few days there as the company's guest before flying back to Illinois. He has had many other job offers, but has not yet decided which one he will accept.

Many honorary fraternities have recognized Phil's enviable ability. He was initiated into Tau Beta Pi, honorary engineering fraternity, Phi Eta Sigma, freshman honorary fraternity, Pi Mu



PHILIP KENTON TRIMBLE

Epsilon, honorary mathematics fraternity, and he is national magazine reporter for Eta Kappa Nu, honorary electrical engineering fraternity.

Phil also enjoys tinkering with his Plymouth and playing intramural basketball. With all this Phil still finds time to eat and sleep, which amazed this reporter.

The *Technograph* wishes the best of luck to Phil in all his future undertakings. If he does as well in the future as he has done in the past, we can expect to hear a lot more about this outstanding electrical engineer.

DR. JOHN D. RYDER

In the midst of his third year at the helm of the electrical engineering department, Dr. John Ryder is busily engaged in his many channels of activity, among which is the preparation for the formal dedication of the electrical

(*continued on page* 44)

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skimming industrial headlines

edited by Charles LaRobadier, m.e. '55

radio-controlled airborne lifeboats

The completion of final acceptance tests on a new radio control for an airborne lifeboat that can be dropped by parachute from an airplane and unerringly guided to survivors in the water has been announced by Westinghouse.

An electrical control system that uses the radio signal from the air to control the engine and equipment for driving and steering the boat has successfully passed trial runs at Lake Pymatuning

This new automatic airborne lifeboat with fins is radio-controlled (Courtesy of Westinghouse)

and final tests conducted by the Air Force at Mobile, Alabama.

The control system for the lifeboat was designed around a radio transmitter-receiver set developed at Wright-Patterson Air Force Base, Dayton, Ohio.

After the 30 *ft.* long craft is dropped by parachute into the sea from the rescue airplane, radio signals at five different frequencies take over complete control in individual stages. The stabilizing fins that hold the boat steady as it leaves the plane are jettisoned. A guard protecting the propeller and rudder is freed. The engine air vents are opened. The motor is cranked up and automatically choked. Following this, the clutch is engaged and the throttle advanced to send the craft forward under the guidance of the radio controller.

When the lifeboat reaches the survivors, the airborne operator can bring it to a halt until the survivors board and then set the boat on its course again. If the physical condition of the rescued men is good, they can take over control of the boat themselves. If they are too weak for this, the airborne operator can guide them to shore or a rescue ship. The boat is equipped with triple controls, permitting passengers to break off radio control at any time and operate it electrically or manually.

"To activate the boat's power plant," explained Thomas A. Daly, managing engineer, "requires an electrical control system incorporating electronic amplifiers, relays, and actuators. Each signal is used to perform a specific group of functions, and the electrical system is so designed that it carries out each duty separately and in the proper order."

The first set of operations after the boat strikes the water consists of five separate stages described above. The radio signal controlling these functions is transmitted to the boat at a frequency of 955 cycles a second. Another radio signal—this one at 3000 cycles a second—now goes into action. The gear shift is advanced from neutral to forward and at the same time the throttle is advanced to half speed. To turn the boat left, a radio signal of 650 cycles acts on the magnetic compass steering mechanism. For a right turn, a signal of 300 cycles is used. For emergencies, a fifth frequency of 1390 cycles is used. A push-button control is also available.

The 3500 *lb.* craft can hold 15 men, with provisions for 10 days and fuel for an 800 *mi.* cruise. It is also equipped with "walkie-talkie" radio sets for boat-plane communications, a machine for distilling fresh drinking water from sea water, and a protective canopy.

radar raincoat

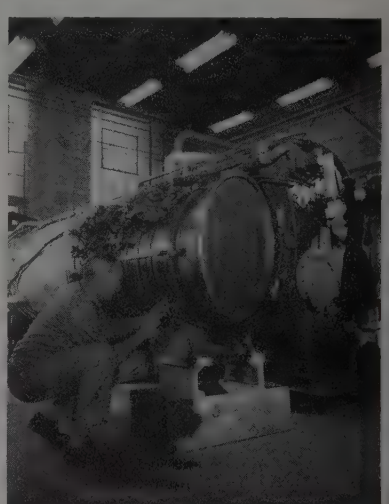
Radar equipment can be protected by a huge, balloon-like radome. The purpose of the rubber-fabric radome is to protect the radar antenna from wind, snow, and ice, without hindering its operation. An aluminum framework is used to raise the huge balloon, which is 167 *ft* in circumference and 36 *ft* high. After the balloon is inflated to one twentieth of a pound of air pressure, the framework is lowered into the floor. When inflated to a half pound of pressure, the radome will withstand winds up to 125 *mph*. Special infrared lamps trained on the walls keep the radome free of ice and snow. Entrance is through an air lock chamber.

a solid, high-temperature lubricant

Molybdenum disulfide is a superior lubricant for moving parts that operate too hot for ordinary oils and greases. It can be used readily at temperatures up to 700°F, and in some cases, even up to 2100°F for short periods and in inert atmospheres. Formerly available only in the form of powder, in a water suspension, or as an additive to greases, it can now be had in solid or stick form. The molybdenum sulfide, with a slight amount of phenolic binder, is molded into desired solid form by heat and pressure. Sticks or brushes of molded lubricant can be held by spring pressure against the rotating member so that some of it is wiped onto the hot surface.

wooden jet

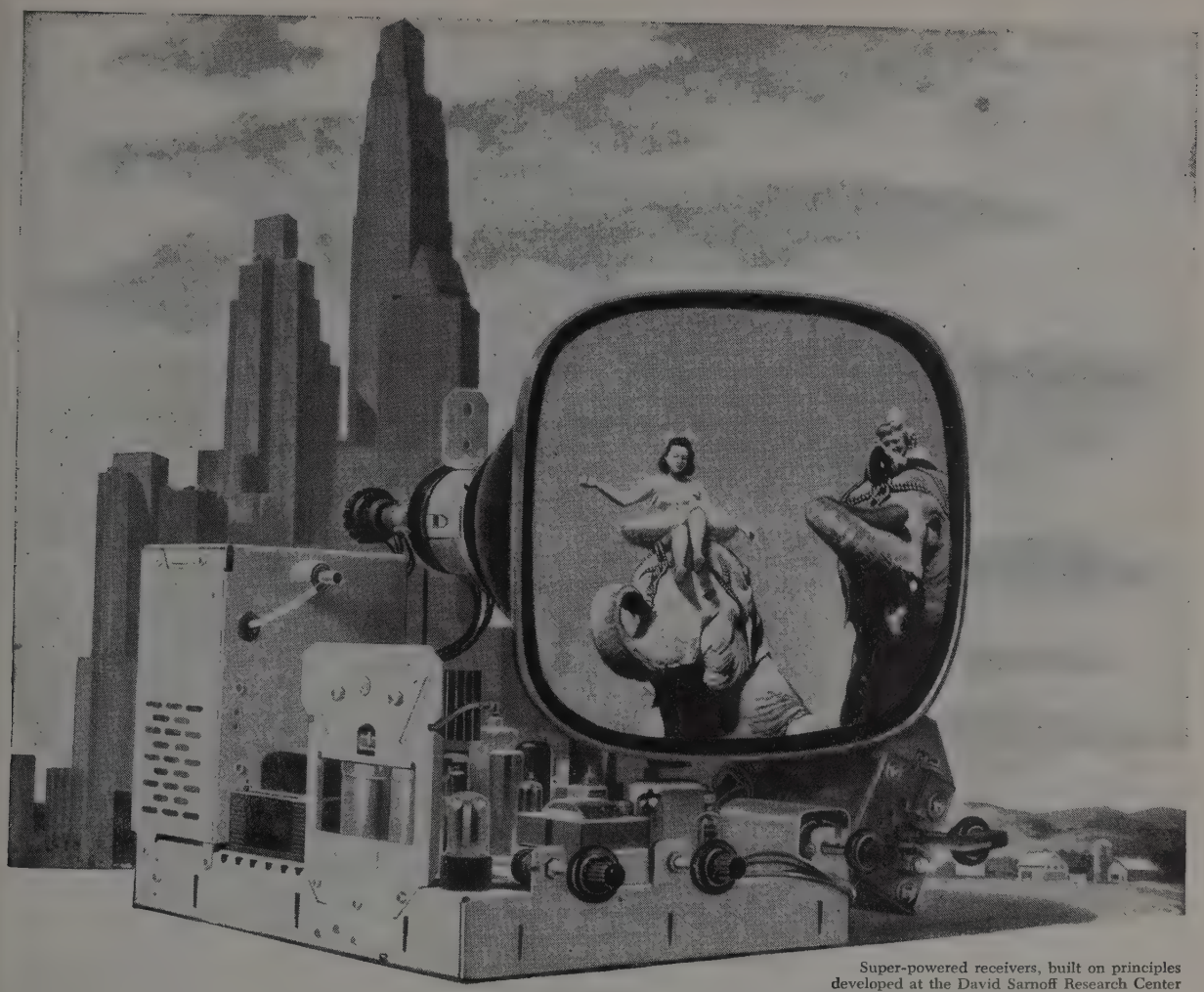
Wood, glue, and screws are virtually the only materials in the mock-up J-40 jet aircraft engine being built by Westinghouse. The model is a precise replica



Wooden model of jet engine facilitates allowances in design alterations. (Courtesy of Westinghouse)

of stainless steel and aluminum engines that are now in quantity production for the U. S. Navy. The wooden engine enables airplane designers to make the

(*continued on page* 40)



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RCA engineers and scientists, to offset these limitations, developed powerful new Super Sets. In distant fringe areas, these sets boost a weak or faltering signal into a clear, steady picture. While in cities, where buildings and electrical devices may interfere, this same super power—plus television's first double-shielded tuner—bring in TV at its best. The result is stronger pictures in the country and in problem areas, and better pictures than ever before in areas of normal television reception.

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SERVO SYSTEM . . .

(*continued from page* 15)

terms in the complementary function would be

$$(B_1 + B_2t + \ldots \quad \ldots + B_mt^{m-1})\, e^{(\alpha+j\beta)t}$$
$$+ (C_1 + C_2t + \ldots \quad \ldots + C_mt^{m-1})\, e^{(\alpha-j\beta)t}$$

which by the above transformation could be written

$$e^{\alpha t}[(D_1 + D_2t + \ldots \quad \ldots + D_mt^{m-1}) \cos \beta t$$
$$+ (E_1 + E_2t + \ldots \quad \ldots + E_mt^{m-1}) \sin \beta t]$$

A pair of imaginary roots can then be seen to assume the form

$$B_1e^{j\beta t} + B_2e^{-j\beta t} = C_1 \cos \beta t + C_2 \sin \beta t$$

and in the case of a pair of imaginary roots of multiplicity m, the final form would be

$$(B_1 + B_2t + \ldots \quad \ldots + B_mt^{m-1}) \cos \beta t$$
$$+ (C_1 + C_2t + \ldots \quad \ldots + C_mt^{m-1}) \sin \beta t$$

In the preceding discussion it was shown that if the polynomial in a (appearing in equation 4) has a real root, there will appear a corresponding term in the complementary function of the form $B_1e^{(\alpha_1+j_0)t}$, for each pair of complex roots, a term of the form $e^{\alpha t}(C_1 \cos \beta t + C_2 \sin \beta t)$; and for each pair of imaginary roots, a term of the form $C_1 \cos \beta t + C_2 \sin \beta t$. Then considering the physical significance of these various types of terms, it can be seen that if there exist a pair of pure imaginary roots, the response to any sort of disturbance to the servo system will be an oscillation that will remain constant in amplitude with time. Since this condition is for most uses as undesirable as a response that will increase with time, for most applications such a root will be classed as indicating instability.

A pair of imaginary roots occurring more than once will produce a term of the form $f(t)C_1 \cos \beta t + g(t)C_2 \sin \beta t$ which indicates that any sort of system disturbance will produce oscillations whose amplitude will increase with time. This situation will be considered as unstable for any application.

In all the cases where a root of the polynomial of equation 4, contains a real part, the role of the exponential $e^{\alpha t}$ will be dominant in determining whether or not the disturbance will disappear with time. So for any case where the root contains a real part, it is not necessary to consider the possibility of multiple roots. If the root has a negative real part, the corresponding term in the complementary function will contain as a factor $e^{-\alpha t}$ and the system disturbance that this term represents will be such that it will decay with time. On the other hand, a root with a positive real part will represent a disturbance whose amplitude will increase with time.

Perhaps it should be remarked at this time that when the statement is made, that an amplitude will increase with time, this is only strictly true as long as the assumption of linearity can be made to apply. Once the amplitude of the disturbance has increased to the point where the behavior of the system parameters has become non-linear, the amplitude will be governed by the non-linear behavior of the parameters. In any event such a situation is distinctly undesirable in a servo system.

From the standpoint of the classical analysis of transient behavior, the problem of determining the stability of a servo system resolves into the problem of examining the polynomial of equation 4 for roots that are either pure imaginary or that have positive real parts.

If the degree of the polynomial in a is three or less, the most direct approach would be to solve the equation and determine the roots. However, in most servo systems the resultant polynomial in a will be of a degree greater than three and in some cases considerably greater than three. In such cases a direct solution becomes impractical and recourse must be made to one of the various mathematical schemes devised to determine the presence of pure imaginary roots and roots with positive real parts.

Edward J. Routh, in a book published in 1859, outlined a simple test for determining the sign of the roots of a polynomial. If the coefficients of the polynomial of equation 4 are arranged in the following manner and the tables constructed in the manner shown until the final row contains only one element, the Routh criterion of stability can be applied.

A_0	A_2	A_4
A_1	A_3	A_5
$B_1 = A_1A_2 - A_0A_3$	$B_2 = A_1A_4 - A_0A_5$	$B_3 = A_1A_6 - A_0A_7$
$C_1 = B_1A_3 - A_1B_2$	$C_2 = B_1A_5 - A_1B_3$	. . .
$D_1 = C_1B_2 - B_1C_2$	. . .	. . .

Then all the roots of the polynomial will have negative real parts if the coefficients $A_0, A_1, A_2, \ldots, A_n$ are positive and all the calculated terms $B_1, B_2, \ldots; C_1, C_2, \ldots; D_1, D_2, \ldots$; etc. are positive or zero.

Figure 1

The complete path of investigation in the complex a plane

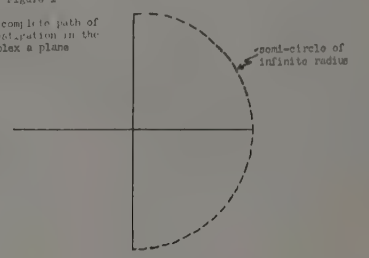
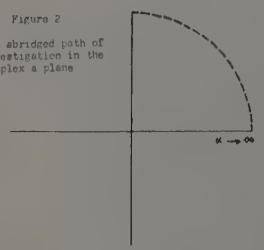


Figure 2

The abridged path of investigation in the complex a plane

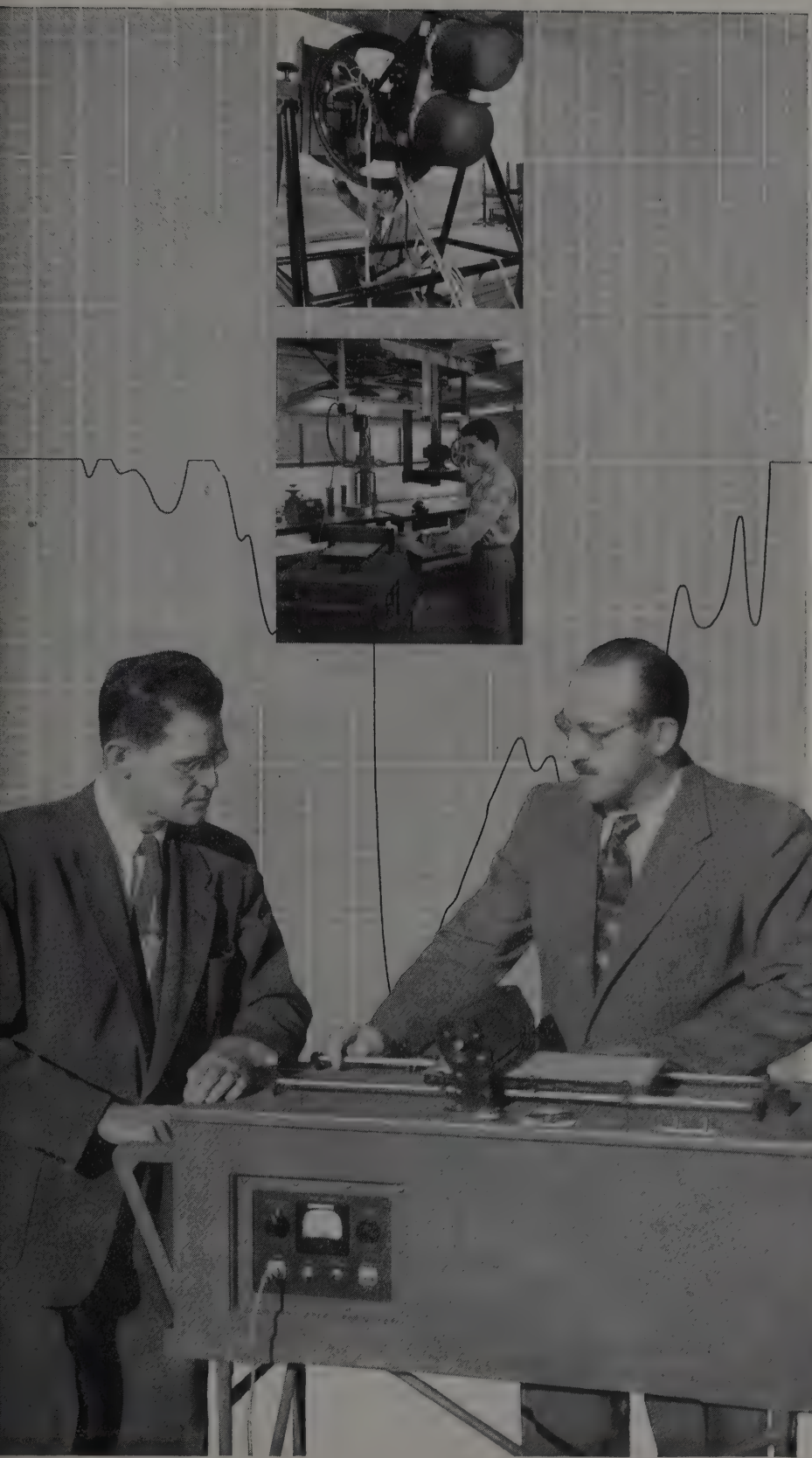


There exists another method of examining the polynominal of equation 4 for the presence of roots whose real part is either positive or zero. This method is called conformal mapping and is a development of the theory of complex functions. Stated in general terms, the idea of conformal mapping is this. Let z be a complex variable of the form $Z = x + jy$ and let w be a single valued functional relationship such that $w = f(Z) = u(x,y) + jv(x,y)$ Now if, and only if, the function w is analytic when it is defined as $w = f(z)$ will it satisfy the Cauchy-Riemann differential equations,

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} \quad \text{and} \quad \frac{\partial v}{\partial x} = -\frac{\partial u}{\partial y}$$

Further, let R be the region of the complex z plane for which $w = f(z)$.

(*continued on page* 30)



Plotters. *O. A. Tyson (left) and Dr. L. C. Van Atta worked together in developing this new machine at Hughes Research and Development Laboratories.*

by Bob Schrader, ch.e. '54 and Warren Brandt, c.e. '54

Well, readers, this month you get a break. I imagine that after a year and a half you are getting pretty tired of my Bilge. So, this month I take a vacation. Let's go back and see what some of the Bilge writers before my time had to say. This first joke, excuse me, I mean anecdote, comes from the original Bilge column written in October, 1949.

Dr. Comings, high pressure man in the ChE department told the following to his victims in thermo last spring.

One day while making the rounds of his ark, Noah was taking census of the animals aboard. After finding seventeen rabbits, five squirrels, three giraffes, etc., he came upon two lonely snakes—the same ones he had brought aboard.

"Why haven't you multiplied like the other animals on the ship?" asked Noah. "We're adders," was the simple reply.

As the original Barnum continued his rounds he noticed the shortage of furniture for his horde. After summoning his old friend, P. Bunyan, Noah built some crude-looking log chairs and tables.

Three days after installing them aboard the ark, he was suddenly confronted with a family of five snakes. "But I thought you couldn't multiply!" he blurted.

Happily papa snake replied, "We used your new log tables."

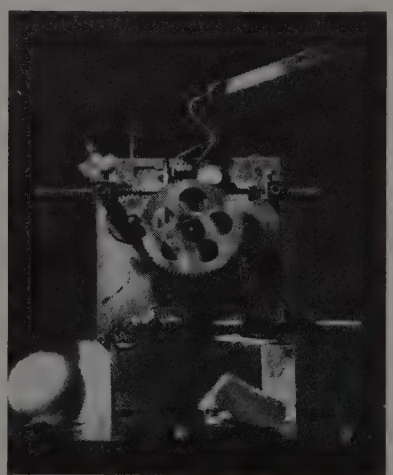
* * *

THE ART OF SLEEPING IN CLASS: It is a fairly well accepted fact that engineers get less sleep than any other students. To make up for this lack of nocturnal bliss, the student must resort to some other means. The most practical solution is to sleep in class. This method is frequently practiced and has thus become an art.

The most practical time to sleep is during a lecture. It will frequently be found advisable to take a seat near the rear of the room where you may black out unnoticed by the instructor. (Some inconsiderates have definite ideas as to seating arrangement.)

One problem in this particular case is that of keeping the note book or clipboard on the desk. The object may easily slide to the floor, thus requiring an unnecessary amount of energy to retrieve it at the end of the period. Also, certain people receive tremendous pleasure from accidentally pushing a clipboard to the floor. The clipboard lands with a resounding clatter, waking both instructor and students. I have found that resting either an arm or the head on the memorandum usually will help.

The position to be assumed for napping will vary with the type of seat in the classroom. I suspect that many chairs were designed for the express purpose of keeping the student awake. The backs of most chairs are so constructed that resting the head on the back (of the chair) is the best solution. This, however, presents the possibility of snoring.



Walter T. Murch's "The Motor" won a Purchase Award at the University's recent 1952 Exhibition of Contemporary American Painting.

Sleeping with the arms supporting the head may result in disaster. I nearly lost my head once.

In classes where discussion prevails, other problems arise. Instructors in such classes may object to this state of activity. A friend of mine has solved this problem by learning to sleep with his eyes open, a process which I have not yet mastered.

It may be embarrassing to come to just as the instructor is asking you a question. Robert Benchley, in an essay on "Dozing" suggested a reply of, "Well . . . I . . . don't . . . know." In the classroom, however, this may be of little or no help.

M.E.'s and C.E.'s may find it extremely difficult to sleep in drawing rooms. The stools are most uncomfortable. It may even be necessary to sleep while standing. A roving instructor will not help matters any.

For the novice, it may be necessary to spend a few nights with less than the usual ten hours sleep to get into form. Pills guaranteed to keep you awake will help to induce sleep. Though the are may never be fully perfected, one should not become discouraged, for even the cruder methods will produce the desired results of lengthening one's doze period.

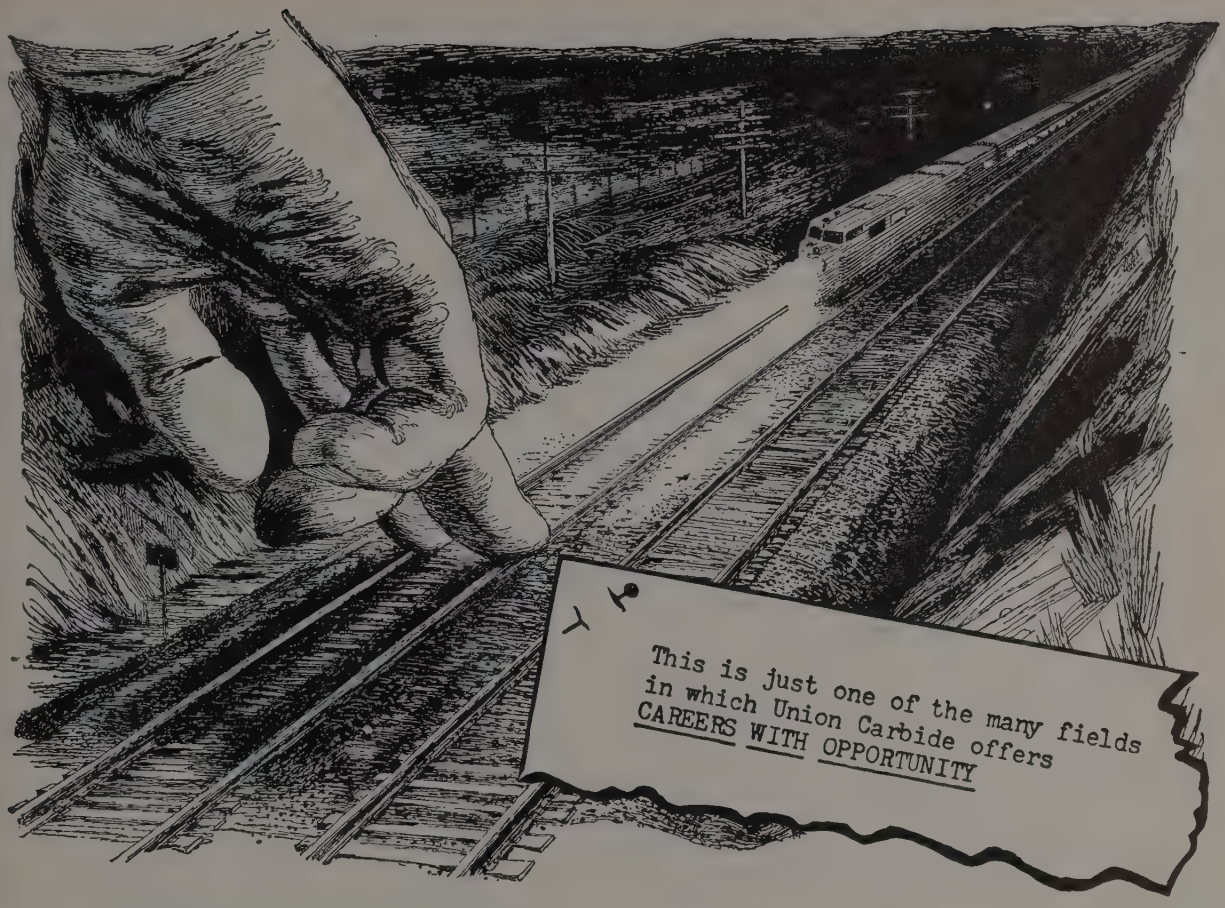
* * *

TIME MAGAZINE COMMENTS ON TECH SPEAKER

No stranger to the *Technograph* is Prof. Eugene I. Rabinowitch, U. of I. physical chemist and Editor of the *Bulletin of the Atomic Scientists*. Professor Rabinowitch addressed the 1951 *Tech* banquet, but his greater fame lies in his editorship which arose from his participation in the A-bomb project while at the University of Chicago.

Time magazine in its 21 April issue has characterized the *Bulletin of the Atomic Scientists* as a sort of 'voice

(*continued on page* 28)



Clearing the track of clickety-clack

You can ride in comfort on longer-lasting rails because the song of the track is being stilled

Like the paddleboat whistle on the river, the clickety-clack of wheels on rails is on its way to becoming a memory.

This familiar clatter and chatter has been like music to some of us when we travel. But it's been a headache to others . . . particularly our railroads.

Wheels pounding on rail joints cause jolting and wear as well as noise. And wear means expensive repair or replacement of rails and the bars that connect them.

ELIMINATING RAIL JOINTS—"Ribbonrail" is becoming important news because it provides a way to solve the high cost of joint maintenance by eliminating the joints themselves.

RAILS BY THE MILE—"Ribbonrail" is formed by welding the rails together under pressure in the controlled heat of oxy-acetylene flames. The welding is done on the job before the rails are laid . . . and they become continuous ribbons of steel up to a mile or more in length.

Mile-long lengths of rail in use may seem impossible because of expansion and contraction under extreme changes in weather and temperature. "Ribbonrail" engineering has solved this problem . . . reduced rail maintenance cost, and created the comfort of a smoother, quieter ride.

A UCC DEVELOPMENT—"Ribbonrail" is a development of the people of Union Carbide. It is another in the long list of achievements they have made during 40 years of service to the railroads of America.

STUDENTS and STUDENT ADVISERS

Learn more about the many fields in which Union Carbide offers career opportunities. Write for the free illustrated booklet "Products and Processes" which describes the various activities of UCC in the fields of ALLOYS, CARBONS, CHEMICALS, GASES, and PLASTICS. *Ask for booklet B-2.*

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NATIONAL Carbons • ACHESON Electrodes • PYROFAX Gas • HAYNES STELLITE Alloys ELECTROMET Alloys and Metals • EVEREADY Flashlights and Batteries

BILGE . . .

(*continued from page* 26)

crying in the wilderness,' the wilderness being the general public apathy to the A-bomb and other problems arising from the progress of science including restrictions on scientific freedom. *Time* is quick to point out that the *Bulletin* is read and quoted by a great number of prominent thinkers around the globe. Its subscription list includes forty in the countries behind the Iron Curtain including the USSR. The *Bulletin's* editorial board features such prominent names as J. Robert Openheimer, Harold C. Urey and Albert Einstein.

Rabinowitch himself has crusaded through the *Bulletin* for free exchange of scientific information and the *Bulletin* speedily got into action to force a lifting of U. S. Commerce Department's restrictions on the mailing of U. S. scientific and technical publications to foreign addresses. Russia's Vishinsky proclaiming agreement with freedom of scientific information exchange with the West, but charging the West and particularly America with obstructing this freedom, brought this comment from Rabinowitch, "We challenge Mr. Vishinsky and the editors of the Moscow *News* to protest the Soviet restrictions on the mailing abroad of Russian scientific journals as vigorously as American scientists have protested the American counterpart; and we hope they will succeed as promptly and as completely as we did on our side."

Bringing to light the cultural and social implications of the bomb and scientific progress is Professor Rabinowitch's aim through the *Bulletin,* a readable, soft paper job, tailored for the general public; and the *Technograph* is happy to approve heartily of this vital, timely project on international problems that must be mastered if world peace is to be a reality.

* * *

TECHNOGRAPH RIDES THE LAST OF THE JUICECARS

The *Technograph* officially represented by its Illustrations Editor, Warren H. Brandt participated in the final run of the Illinois Terminal Railroad's train operating westward out of Danville. The railroad terminated operations on the line between De Long Station and Danville and ran the last train Saturday 26, April, 1952. Brandt accompanied, by his friend, Art Eggers, grieved the loss of this important connection with the Twin Cities, Urbana-Champaign.

One hundred and fifty railfans and a few regular commuters were aboard and were greeted by scores of photographers at each station of the abandoned line. Abandoning railroads seems to be a step backward though, doesn't it?

From Professor Alexander of our Chemistry Department we quote the following words which we feel can relate to many of our subjects: "Teaching organic chemistry is like pouring H_2O into a sieve. The only hope is that it will run out slowly enough to last through each hour exam.

* * *

One of the E.E. profs here was heard to make the following enlightening statements:

An LAS student knows nothing, and he can do nothing.

A math major knows everything, but he can do nothing.

An engineer knows nothing, but he can do everything.

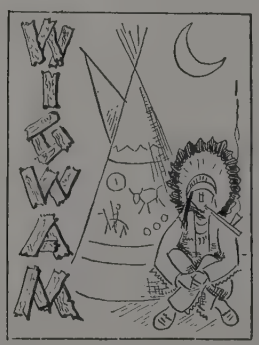
A commerce student knows nothing and can do nothing, but he gets paid for it.

A true music lover is a person who, when he hears a soprano in the shower, puts his ear to the keyhole.

* * *

It's almost old-fashioned now to believe in love at first sight, or even love at first marriage.

HEAP BIG HUNTING GROUND FOR HAPPY SLIDE RULES



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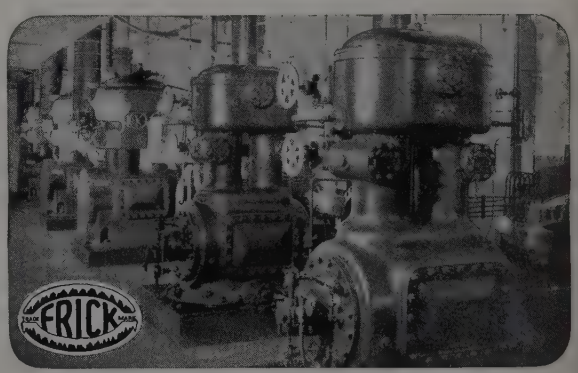

Snow Crop Marketers Install Frick Refrigeration

Snow Crop Marketers, a Division of Clinton Foods, Inc., and one of the largest packers of quick-frozen foods in the country, has in operation at Lewiston, Idaho, a battery of five large Frick compressors which produce temperatures as low as minus 40 degrees F. Installation by Lewis Refrigeration and Supply Co., Frick Sales-Representatives at Seattle.

Super-dependability and economy have made Frick refrigerating machines the favorite with quick-freezers, as well as in air conditioning, ice making, and other cooling systems.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years offers a career in a growing industry.

DEPENDABLE REFRIGERATION SINCE 1882

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What's Happening at CRUCIBLE

about special shape type steel

5. The flash trimmed off after the swadging operation.

6. The finished type ready for hardening, plating and soldering to the type bar.

The production of Crucible steel for this job is the result of engineering and practical know-how combined with a special method of manufacture to assure a homogeneous microstructure for maximum forming properties, excellent surface characteristics for good die life, and close accuracy control for all dimensions of the shape.

The production of type steel requires the use of small precision rolling mills equipped with shaped rolls and operated by skilled workmen. During preliminary and final inspection, shadowgraph equipment is constantly used to check for size accuracy.

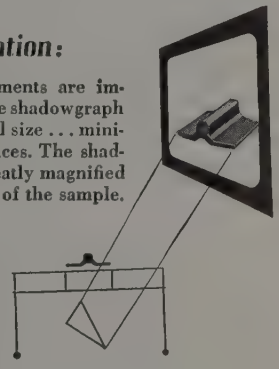
As a result of its outstanding quality, Crucible's special shape type steel is constantly in demand and used by leading typewriter manufacturers.

Crucible special purpose steel for type character application

The development of cold rolled special shape type steel is one of Crucible's important contributions to the business machine industry. A major part of the type characters used for the manufacture of typewriters are made from this special shape.

Shadowgraph Operation:

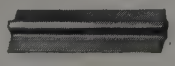
Since micrometer measurements are impractical due to the shape, the shadowgraph is used to measure shape and size . . . minimum and maximum tolerances. The shadowgraph is a projection, greatly magnified . . . on a calibrated screen . . . of the sample.



Schematic of shadowgraph

Here's the step-by-step process:

1. Cold rolled special shape produced by Crucible.



2. The type slug cut from the special shape material.

3. The wings of the type slug are bent down and taper formed toward the edges.

4. The type characters are cold swadged on the solid edge of the bent type slug.

If you have a requirement for special steels—check with Crucible. Feel free to draw on the experience of our metallurgists and engineers. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

52 years of Fine *steelmaking*

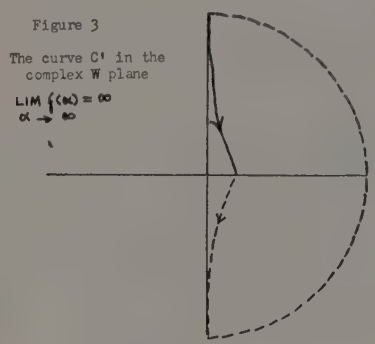
Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa.
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

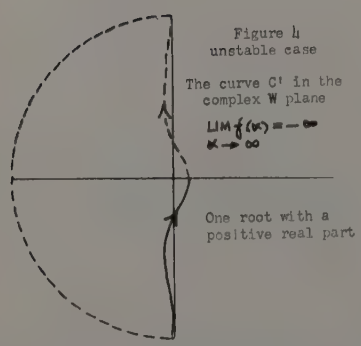
SERVO SYSTEM . . .

(*continued from page* 22)

Then the functional relationship $w=f(z)$ sets up a correspondence between the points $z=x+jy$ of the complex z plane, and $w=u+jv$ of the complex w plane. If $w=f(z)$ is analytic for the region R of the z plane, for each value z in the region R the corresponding value of w will lie in a region R′ of the w plane. If C is some curve drawn in the region R and the point z is allowed to move along C, then the corresponding point w will trace a curve C′ in the w plane. Then if the curve C is drawn in R so that it is a closed curve that encircles in a positive sense a value of z for which $w=0$, the corresponding curve C′ will encircle the zero point of the w plane in a positive sense. The positive sense for a boundary curve C of a region is such that the region will always lie to the left of the curve when proceeding in the positive sense. Further, if the curve C is made to encircle more than one value of z for which $w=0$, the corresponding curve C′ in the w plane will encircle the zero point once for each value of z so enclosed by C. If the curve includes as one of its points a value for z for which $w=0$, then the curve C′ will pass through the zero point of the w plane once for each such value of z.

It can be shown that the polynomial occurring in equation 4 will be analytic over the entire complex z plane. Then the theory of the preceding section can be applied directly to the polynomial in a. The path C is chosen to be the path shown in figure 1, that is, the imaginary axis and a semi-circle of infinite radius that will enclose all finite values of a with positive real parts. Let the polynomial be defined to be $w=f(a)$. Then if a conjugate pair of pure imaginary roots of f(a) exist, the curve C′ will pass through the zero point

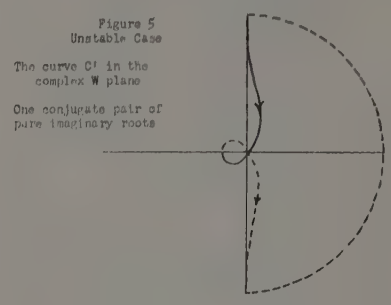


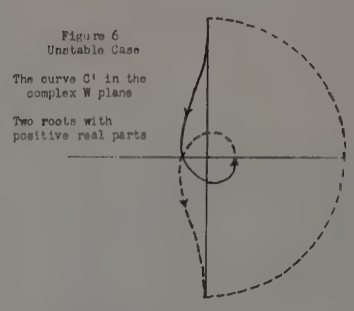


twice, and for each root of f(a) with a positive real part, the curve C′ will encircle the zero point once in a positive sense.

Since it has been previously remarked that any complex or imaginary roots will occur in conjugate pairs, it can be seen that the portion of the curve C′ that is traced when a ranged over the values along the imaginary axis will be symmetrical with respect to the real axis. Thus it would be sufficient to investigate the behavior of the curve C′ for a ranging from zero to positive infinity. Further, since for any infinite value of a the function f(a) will be infinite, the location of the portion of C′ resulting when the infinite semi-circle portion of C is traced could be established by substituting $a=\alpha+j0$ in f(a) and determining whether $\lim_{\alpha\to\infty} f(\alpha)$ equals positive or negative infinity. The accompanying figures 2, 3, 4, 5 and 6 give the probable shape of the plots illustrating each of these situations.

At the beginning of this paper it was assumed that the simultaneous set of n differential equations describing the servo system could be reduced to a single





characteristic equation with the same mathematical properties. It is not necessary to do this. If instead an exponential solution is assumed for each abridged equation of the set, the result will be a set of n simultaneous equations each of the general form of equation 4. If the determinant of this set,

$$\begin{vmatrix} a^n & A_{11}a^{n-1} & \cdots & A_{1n-1}a & A_{1n} \\ a^n & A_{21}a^{n-1} & \cdots & & A_{2n} \\ \cdot & \cdot & & \cdot & \cdot \\ \cdot & \cdot & & \cdot & \cdot \\ \cdot & \cdot & & & \cdot \\ & & & & \\ & & & & \\ \cdot & \cdot & & & \cdot \\ \cdot & \cdot & & & \cdot \\ \cdot & \cdot & & & \cdot \\ a^n & A_{n1}a^{n-1} & \cdots & & A_{nn} \end{vmatrix}$$

is expanded it may be examined for roots whose real parts are positive or zero in the same manner described for the polynomial of equation 14.

In conclusion, the author wishes to acknowledge the advice and guidance of Mr. L. O. Brown, of the electrical engineering staff of the University of Illinois.

What Are They?

- ☐ *Thrust bearings*
- ☐ *Clutch disks*
- ☐ *Grinding wheels*
- ☐ *Ceramic insulators*

The correct answer is grinding wheels, shown as they emerge from the electric kiln.

Not ordinary grinding wheels, however. They are Norton *New-Process* Wheels — made by modern, streamlined, precision methods developed by Norton engineers.

A Big Step Forward

This new process involves advanced equipment, new manufacturing techniques, and close quality control during every step of grinding wheel production. As a result, Norton *New-Process* Wheels are produced to a degree of structural uniformity never before possible.

This increased uniformity means extra assurance of consistent grinding action throughout each wheel and from wheel to wheel. Which, in turn, means more evenly wearing, longer lasting wheels — together with more cutting action per wheel and per dollar.

In addition, the built-in balance of Norton *New-Process* Wheels cuts down vibration and enables them to hug the work more closely, assuring smoother, better grinding performance.

A wide range of wheels employing both ALUNDUM* (aluminum oxide) and CRYSTOLON* (silicon carbide) abrasives are made by the new process.

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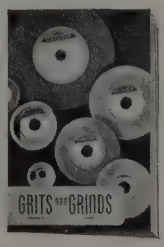
Geared to industry's constantly expanding needs, Norton Company serves *every* manufacturing field by "making better products to make other products better." Young men planning technical careers are invited to consider the established leadership and far-ranging scope of the Norton world-wide organization.



Send For Additional New-Process Facts

Recent Norton literature gives further details on this important advancement in grinding wheel manufacture and performance. Write for your free copy.

John J. Amero, M. S., Cer. Eng., North Carolina State '38, checks duplication of grinding wheel grade with the aid of an oscillograph. John has been working on the development of Norton "New Process" wheels.

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EE DEPT . . .

(*continued from page* 11)

the solution of complicated electrical networks. In this country, power distribution systems are interconnected from east of the Rocky Mountains to the east coast. This presents a vast, extremely complicated network which would be impossible to solve using manual methods. The network analyzer shows the effects on the whole system of adding a load, such as a factory, or cutting out a generating station.

The network analyzer here at the University is the largest of its kind in any educational institution. The only larger such unit is owned by General Electric and is located in Schenectady. To cut down the size of the elements used in the analyzer and also to reduce its power consumption, it is operated at a frequency of 10,000 cycles per second, as compared with 60 cycles as furnished by power companies. A factory can be represented by an inductive load, that is, a load composed of coils. Since the magnitude of the load represented by any given coil is directly proportional to the frequency, it can be seen that a much larger load can be represented by a coil at 10,000 c.p.s. than by the same coil at 60 c.p.s.

The analyzer was designed by Dr. John D. Ryder, head of the department, and Professor Max A. Faucett. It is one of two 10,000 cycle analyzers, the other being designed by Dr. Ryder for Iowa State college.

Since the machine provides solutions to simultaneous equations, its usefulness is not confined to electrical networks, but it will also be used for fluid flow problems and stress analysis.

There are 389 electrical engineers enrolled in the department's three options, most of these in the electronics and communications option. Electrical engineers here at the University take the common program for freshmen as do other engineers, and all options take a common program the second year. In their junior year, the E.E.'s begin to branch out into their individual options, the power men concentrating more on power machinery, transformers, and the like, while communications men study networks, lines, electronics, and radio circuits.

The illumination men get some architecture courses, many lighting courses, some power machinery and electronics. Sales management and psychology are also required in this option.

Besides handling the three E.E. options, the electrical engineering department offers courses to non-electricals who must take some electrical engineering courses. These include M.E.'s, Aero. E.'s and others. Special courses in DC circuit analysis and electrical measurements are offered to these students.

Research in the department is conducted largely by a special research staff. Some of these men conduct lab courses in the department, but their main work is research.

At present, research is being conducted in several fields. Television field strength measurements are being made, and the effects of antenna design are being investigated. Miniature vacuum tube research is being conducted in the research laboratory.

One interesting field of study concerns the effects of large eddy currents on concrete reinforcing bars. Modern power plants are handling larger and larger amounts of current. These larger currents induce extremely high magnetic fields and the fields in turn set up currents in the surrounding structural steel. In some cases, these so-called eddy currents are so high as to heat up the reinforcing bars in concrete to the point where they become structurally unsound. Research in this field will attempt to solve these problems brought about by the increased power handling capacities of present-day generating stations.

Research is being conducted to find out the effects of ground potentials on

(*continued on page* 42)

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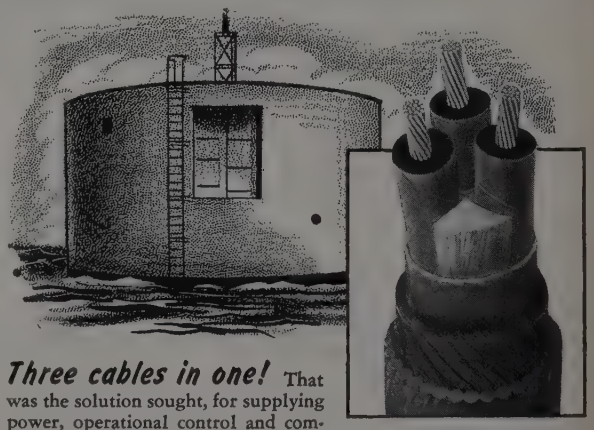


Three cables in one! That was the solution sought, for supplying power, operational control and communication to a pumping house 4½ miles off shore in Lake Okeechobee, Florida.

As usual, Okonite engineers were consulted on the problem. Their studies showed that it was possible to combine a three-fold function in one cable. This was accomplished by the use of Okolite high-voltage insulation whose electrical characteristics permitted carrier current to be superimposed on the power conductors.

The result was a single Okonite-insulated cable—steel-armored for the 4½ underwater miles, with a non-metallic sheath for an additional 2½ miles underground—which supplies not only power and operation control, but a communication circuit as well.

● ● ●

Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE *insulated wires and cables*

8787

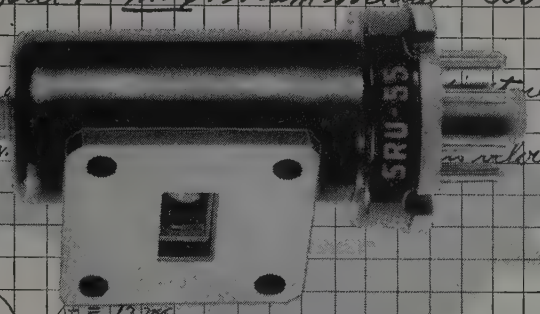
ORDER NO.
SUBJECT Reflex Klystron Oscillator NAME R. Brown DATE 1/23/51

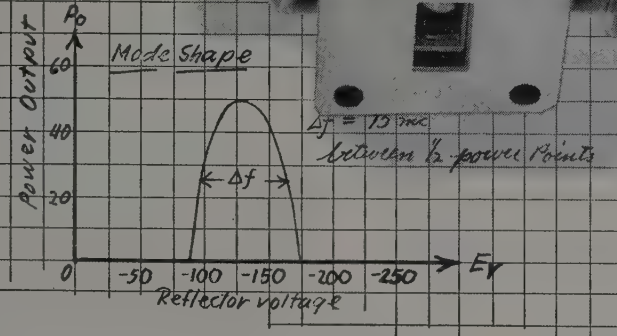
Requirement:— A wide-band klystron in Ku band which operates at low voltage (less than 350 V.)

Choice #1 :— Type SRU-55 reflex klystron

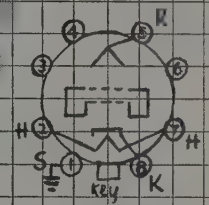
Data :— Covers range from 14000 mc to 17500 mc. (3500 mc, 22% band)
15-60 m.w. output. Max. beam voltage = 350 V.

Tuned by means of ... element.
Waveguide ... 0.702" X 0.391 W. ... below 70°C.





Δf = 15 mc between ½ power Points



Octal Base
1. Shell, B+ (Gnd.)
2. Heater
5 Refl. (all other Pins are Int. Conns.)
7 Heater
8 Cath.

...WIDE TUNING RANGE WITH

LOW-VOLTAGE KLYSTRON 14,000 to 17,500 MC at 300 VOLTS

Type SRU-55 is a low-voltage, reflex klystron oscillator with radio frequency output of 15 to 60 milliwatts, operating over the frequency range of 14,000 to 17,500 mc. This Sperry tube can be used as a local oscillator for microwave receivers or as a bench oscillator in the measurements laboratory.

Keep Learning — But Start Earning ... at Sperry

The klystron tube described here is but one of the many Sperry Klystrons which has resulted from Sperry's sponsorship of the development of the klystron in 1939. From Sperry laboratories have also come a complete line of Microline* instruments for precision measurement in the entire microwave field. In these labs career-seeking engineers keep learning but start earning—work with acknowledged leaders in their fields—do interesting, creative, important work—find the opportunity for advancement as high and broad as their own capacity for improvement.

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Aeronautical, Electrical, Electronic, Mechanical Engineers — Physicists — Technical Writers—Field Engineers for applied engineering here and abroad. *Join the leader.* From Sperry research and engineering have also come Gyropilot* flight controls, Zero Reader* flight director, radar, servo-mechanisms and computing mechanisms. Help us maintain Sperry's unique tradition of leadership through outstanding accomplishment. Write:

Employment Section 1 A 5

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NAVY PIER . . .

(*continued from page* 13)

standing cadet. Harry Hellmuth has transferred to the downstate campus company (chapter).

During the last semester the society has initiated 14 new members.

This semester the society plans to enter a drill squad downstate, at the Illinois invitational drill meet.

This semester the society has planned to bring in some new members. For this reason the membership committee was set up. Dale Smith is the chairman of the membership committee and pledge master. The other men on the committee are Bill Edwards and Anatol Longinow.

The P/Rs are on the lookout for likely pledges who are really interested in the R.O.T.C. Those who might be interested may ask any P/R member more about it. (P/Rs are identified by the blue and white fourragère in their shoulder loop.)

SAME

The student chapter of the Society of American Military Engineers has successfully progressed from its stage of infancy in the fall semester to a smooth running organization. Through the work of the officers, Clifton Zabka, president; John Curtis, secretary; Richard Krammerer, vice president and treasurer, and a close knit organization which has backed them, a rather fine program has been scheduled, with several of the events having already been completed.

Cooperation from E. J. Gress, Chief of Personal, Great Lakes District Engineers, has enabled the society to see several movies dealing with a number of the waterways in the United States and also to hear an informative lecture on taconite, an iron ore bearing rock. The Spring Carnival here at the Pier presented a fine opportunity for the club to enlarge its funds. This was done very profitably, thereby placing the society in a rather solvent state.

During the Easter recess, the society members and other interested students visited the U. S. Steel plant in South Chicago. A fine insight into industry was gained by this tour. In mid-May election and installation of new officers, plus the initiation of new members is to take place during a semi-formal dinner, at which several speakers will be present. To complete this well-rounded program, an outing for members and friends will take place soon after finals.

"Is that man rich?"

"Is he! He's so rich he doesn't even know his son's in college."

CAMP RABIDEAU . . .

(*continued from page* 12)

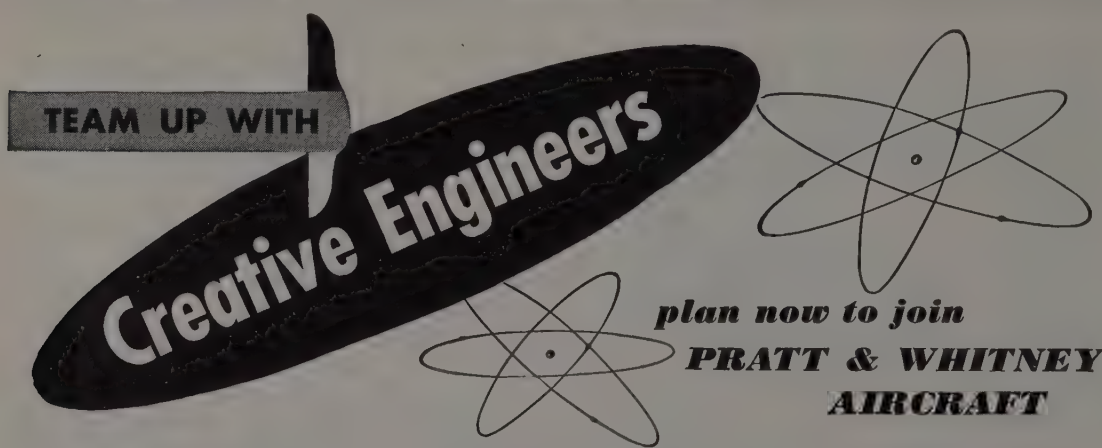
camp and students frequently take side trips to those that are near. These include the headwaters of the Mississippi River at Lake Itasca State Park, Cut Foot Sioux experimental forest, a beautiful stand of pine down Grand Rapids way, and the border cities of International Falls, Minnesota and Fort William, Ontario.

All in all, as a surveying camp, Camp Rabideau turns out a pretty good assembly of surveyors, almost a hundred each summer, but it turns out a goodly number of baseball players, fishermen, and swimmers too.

A student leaving the camp has not only learned surveying but has learned how to accommodate himself to a new and unique experience that is just a little bit different from anything he has come across previously. Without a doubt anybody that has been to Camp Rabideau will tell you he is richer for it and has learned one of the most practical subjects offered in any engineering school.

Co-ed: "Is it natural to shrink from kissing?"

Prof: "If it were, my dear, most of you girls would be nothing but skin and bones."



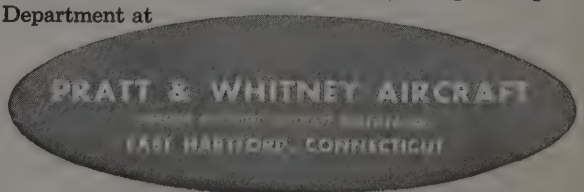
FOR over a quarter of a century the Pratt & Whitney Aircraft Division of United Aircraft Corporation has depended upon *creative engineering* to bring its products to the forefront.

How well this idea has worked is amply demonstrated by the outstanding leadership record which Pratt & Whitney has established in both piston and turbine aircraft engine types.

And for the future, because of its sound engineering background and research facilities, Pratt & Whitney is one of the few companies in the country to be selected to develop an atomic powered engine for aircraft.

Creative engineering will continue to be given top emphasis at Pratt & Whitney—and it might well be the best answer to *your* future too—if you want a chance to put *your own* ideas to work.

Why not find out where you could fit into this great engineering organization? Consult your Placement Counselor or write to Frank W. Powers, Engineering Department at



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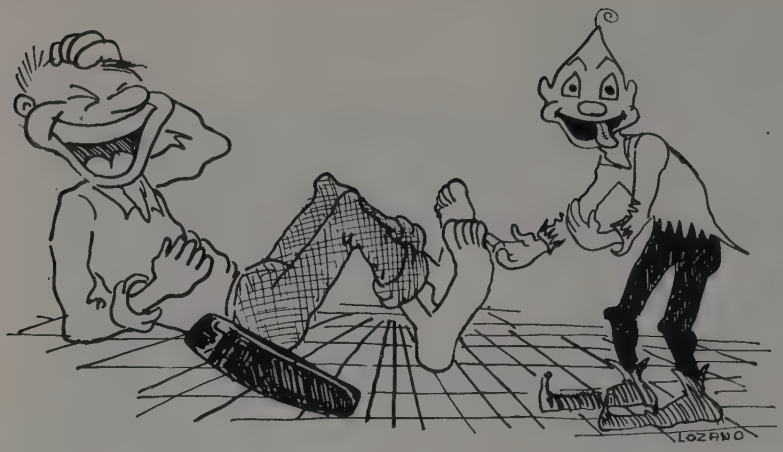


TECHNOCRACKS

edited by Mary Donley

A motor cyclist, in an effort to keep warmer, put his coat on backwards so that the back would better protect the chest. As he sped down the highway a car dashed across his path from a side road and the cyclist was thrown into a ditch. The police soon came along and one of them attended the prostrate cyclist.

"How is he?" asked one cop.

"What a shame!" replied the other. "The poor lad had his head turned around. By the time I got it straightened out he was dead."

* * *

A young theologian named Fiddle
Refused to accept his degree.
For, said he, it's enough to be Fiddle
Without being Fiddle, D.D.

* * *

Doris: "I can't marry John, father. He's an atheist and doesn't believe there's a hell."

Father: "Go ahead and marry him, Doris, you'll convince him."

* * *

"Son, after four years of college, you're nothing but a drunk, a loafer and a damn nuisance. I can't think of one good thing it's done!"

The son was silent a moment. Suddenly his eyes brightened. "Well," he said, timidly, "it cured Ma of bragging about me."

* * *

Senior: "Gee, I'm thoisty."

Frosh: "Wait a minute, I'll get you some water."

Senior: "I said thoisty, not doity."

A canny Scot was engaged in an argument with the conductor as to whether the fare was to be five or ten cents. Finally the disgusted conductor picked up the Scot's suitcase and tossed it off the train just as they were crossing a long bridge. It landed with a mighty splash.

"Hoot, Mon," screamed Sandy. "First you try to rob me and now you've drowned my little boy!"

* * *

Police sergeant: "College student, eh?"

Prisoner: "Yes, sir."

Patrolman: "It's a stall, I searched his pockets and found money in them."

* * *

A maid in the land of Aloha
Got caught in the coils of a boa.
Like arms the snake squeezed,
And the maid not displeased,
Cried, "Go on and do it Somoa!"

* * *

Something to think about:

If we could only sleep as soundly at night as we do when it's time to listen to a lecture.

* * *

Dear Pop,

Everything fine at school. I'm getting lots of sleep and am studying hard.

Incidentally, I'm enclosing my fraternity bill.

Your son,
Pudge.

Dear Pudge,

Don't buy any more fraternities.

Your Pop,
Pop.

I noticed in "Time" that Jacob Horner, a survivor of the battle of the Little Big Horn, died. It seems he survived because he wasn't there.

* * *

There had been an accident. It was the old thing—a student's convertible had collided head-on with the farmer's Model A. The two drivers got out and surveyed the damage. "Well," said the farmer, "we may as well have a drink." He hauled out a bottle and passed it to the student who gulped down a stiff one. The farmer calmly returned the bottle to his pocket. "Aren't you going to have one?" asked the college student. "Don't believe I will," was the answer, "until the police have checked up."

* * *

"Just because my eyes are red is no sign I'm drunk. For all you know, I may be a white rabbit."

* * *

Professor (after the final exam): "Well, what did you think of the course?"

Student: "I thought it was very all-inclusive. Everything that wasn't covered during the year was covered on the final exam."

* * *

A Sultan at odds with his harem
Discovered a way he could scare 'em,
By catching a mouse
Which he freed in the house,
Thus causing the first harem scarem.

* * *

A co-ed trying to maneuver her car out of a parking space banged into the car ahead, then into the car behind, and finally, pulling into the street, struck a passing delivery truck. A policeman who had been watching approached her.

"Let's see your license," he demanded.

"Don't be silly, officer," she said. "Who'd give ME a license?"

* * *

Trying to rest after an exceedingly hard day at the office, poor father was being bedeviled by a stream of unanswerable questions from little Willie.

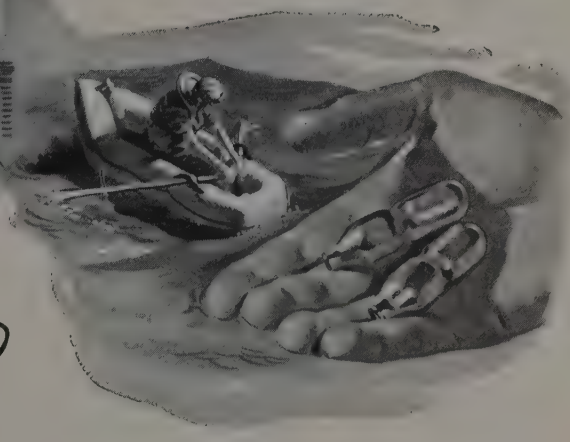
"What do you do down at the office?" Willie finally asked.

"Nothing," shouted the annoyed father.

After a thoughtful pause, Willie inquired: "Pop, how do you know when you're through?"

how large?

The 40- to 75-foot trademarks of a world-famous Thanksgiving Day parade are inflated with helium. Lighter-than-air, this "safe" gas will not burn or explode.



how small?

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CO-OP PLAN . . .

(*continued from page* 16)

become a full-time, instead of a half-time worker.'

There are many advantages to the cooperative system. Since a younger man is more willing to ask questions, practical experience is more readily assimilated in the formative student years. Also the cooperative student frequently brings to class observations gleaned from his shop experience, resulting in a better understanding of the material covered in class. At graduation the student frequently remains with the firm with which he cooperated, or in other cases, his work record is of advantage in establishing a new connection.

Post graduate and cooperative training programs overlap to a considerable degree, thus materially shortening if not eliminating, the post graduate training period. The cooperative system is a very valuable financial aid in completing an engineering education. This system also enables students, mistaken as to their vocation, to change their objective without serious loss of time.

All this may be well, but what do the students themselves think of the system? This question was partially answered in a survey made on two hundred and eighteen engineering students by the Rochester Institute of Technology. First of all the students were asked if cooperative work made their schoolwork more meaningful. Seventy-eight per cent of the students said that cooperative work had made their schoolwork clearer. Similarly 74 per cent of the students said that their interest in school had increased because of on-the-job training.

This poll also brought out some of the weaknesses of cooperative plans. Coordination between the school and the job could be improved. The length of the work block or of the school year itself disturbed some of the students. Cooperative methods of instruction also were criticized, and the heavy class schedule necessitated by cooperative work was pointed out. Also, more social contacts are needed for the student on co-op.

It has not been the purpose of this article to determine whether cooperative or non-cooperative schools present the better form of engineering education. Each individual must decide this by weighing the merits of his own special case. However, it is well to remember that cooperative, as well as non-cooperative engineering schools exist today in America, and that there is definitely a need for both of them.

SKIMMING . . .

(*continued from page* 20)

necessary allowances for size, accessories, and other problems involving the engine's configuration. The wood construction—aside from being inexpensive—also makes it easy for the model shop to keep the engine up to date as its forms evolves from the engineer's calculations.

newly developed automatic pilot

An automatic pilot designed to relieve U. S. Navy fliers of 90 per cent of their "stick and rudder" work was announced recently by General Electric. The device was described as a major step toward complete push-button control of high-speed jet interceptor planes.

Engineers said the new autopilot "does just about everything a human pilot can do except actually take the plane off the ground and land it," controls the plane with accuracy and stability at near-sonic speeds, and can be used in such maneuvers as gunnery runs on enemy aircraft.

Designated the G-3, the autopilot was developed by the GE Aeronautic and Ordnance Systems Division in cooperation with the Navy Bureau of Aero-

(*continued on page* 42)

Engineering Graduates

CONSIDER YOUR FUTURE IN AIR CONDITIONING

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Trane, a leading manufacturer of air conditioning, heating, ventilating and heat transfer equipment, is seeking qualified engineering graduates for interesting careers with its sales and home office staff.

Those selected will join the Trane Graduate Training Program at La Crosse for an intensive training course that will prepare them for responsible positions in La Crosse or in one of the company's 80 sales offices. The training period is financed by the company to make the trainee self-supporting.

Men who have completed the Trane Graduate Training Program have established an interesting pattern of success with the company. Included in this number are the president and numerous other company officers, managers of a majority of the sales offices and home office sales divisions.

Trane has continued to grow steadily and at a rate consistent with financial stability. Annual sales have increased fourfold in the last ten years. Yet, the company continues to develop new products for new fields to increase its potential business opportunities.

Based on past record and future possibilities, Trane offers you outstanding opportunities in one of the fastest growing industries. For more information write for the brochure "The Trane Graduate Training Program." It contains full details as well as a complete financial report of the company.

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You are giving away your standard of living

FANATICS in Germany, India, even some in America, say we should scatter our billions over the world in order to use up our surplus; otherwise (they say) it will dam up on us and cause a depression.

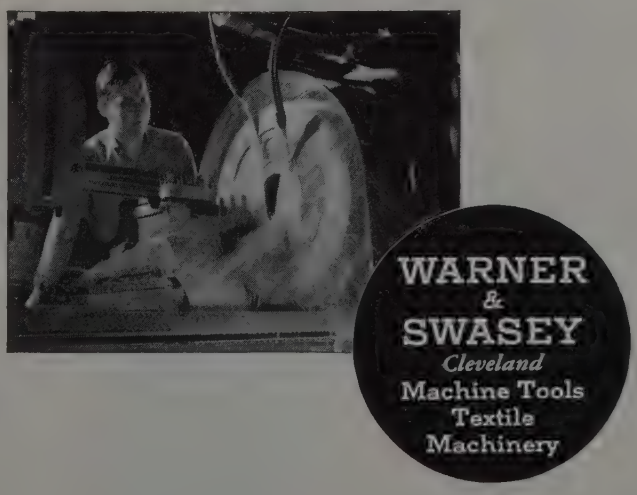
It is entirely possible that we should give away those billions for humanitarian reasons—that is another matter. But don't let's let greedy foreigners and stupid Americans say we're doing it for our own selfish interests. And don't let anyone of us think we are doing it by "soaking the rich". We are giving away (and, remember, perhaps we should, so long as we do it with eyes open) our standard of living.

You and I work, not for dollars but for what those dollars will buy. The more *things* there are in America, the more your day's work and mine will buy. The more steel there is in America, the more automobiles you can get at a low price. The more cloth, the more suits you can own. The more food there is, the better you and your family will eat.

There can only be so much of those things. When you ship them away; you do without. You seldom ship *money* abroad; money is only a token of exchange for the *things* that are going out of this country, out of your reach.

Perhaps that's good, perhaps that's wise. But we should realize what we're doing. Whatever we give away abroad comes out of what we have at home. Unless, of course, each of us produces that much more at his machine or plow or desk *every day.*

If every one of us *produces* more efficiently we can have the satisfaction of knowing we are doing something for the world without destroying America . . . the one strong hope of the world. If we "share the wealth" with the world, we will soon be sharing nothing but poverty. If we share our *increased production* and demand increased production in return, there will then be wealth *and* strength to share.



YOU CAN MACHINE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY TURRET LATHES, AUTOMATICS AND TAPPING MACHINES

SKIMMING . . .

(*continued from page* 40)

nautics. It was designed for use in high-speed Navy jet fighters.

The G-3 will hold the plane automatically at the desired barometric altitude, heading and attitude. The pilot can put the plane through the maneuvers he wishes by means of push buttons and a miniature control stick which moves under finger-tip pressure. When the human pilot wants the autopilot to take over, he pushes a button and the device holds the airplane at the same heading and altitude it was in when the button was pushed. By means of another button, the pilot can change altitude, turn in either direction, or climb and dive.

The G-3 is also used as a "yaw damper" during manual flight to stabilize the airplane and improve steadiness.

Non-tumbling gyros permit the plane to maneuver through complete loops and rolls without disabling the gyroscopes through tumbling.

The G-3 system consists of a G-2 compass, a vertical gyro and a rate gyro which feed electric signals into an amplifier. The amplified signals are then applied to one or more of three motor-driven actuators which move the airplane's control surfaces.

Researchers check purity of hydrocarbons by determining freezing points. (Courtesy of Westinghouse)

air conditioning for greater accuracy

Elimination of variables in precise measurement techniques was a big problem in the addition to the Engineering Hall at Carnegie Institute of Technology in Pittsburgh. Herein is located

(*continued on page* 48)

EE DEPT . . .

(*continued from page* 32)

underground cables. The resistance of the earth varies with the composition in different parts of the country. Electrical energy is capable of traveling through the ground, and these ground currents and voltages affect underground telephone cables and coaxial cables for TV transmission.

The research staff recently completed ORDVAC, the calculating machine purchased by the army, and are now engaged in making another for the use of the University. The machine is a digital computor and can handle calculations in a matter of hours and sometimes minutes that would take a mathematician several years to complete.

The department has been awarded research contracts by the government war and navy departments. This research is confidential, but it is known that some of it is along servo-mechanisms lines. Servos are the devices which power the control surfaces of large planes in response to the touch of the pilot.

That the University is turning out electrical engineers, and good ones, is testified to by the fact that at last count, there were 1.3 companies requesting interviewing time for every available graduating senior. Many other companies have been denied interviews because there just aren't enough men.

According to one professor in the E.E. department, Bell Laboratories employ more graduates of the University of Illinois than all the other E.E. schools put together, a truly complimentary testimonial for the electrical engineering department at the University of Illinois.

"My boy," said the businessman to his son, "there are two things that are vitally necessary if you are to succeed in business."

"What are they, dad?"

"Honesty and sagacity."

"Always—no matter what happens, no matter how adversely it may affect you—always keep your word once you have given it."

"And sagacity?"

"Never give your word."

* * *

"I don't think the man upstairs likes Johnny to play his drum."

"Why?"

"Well, this afternoon he gave Johnny a knife and asked him if he knew what was inside the drum."

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THE DU PONT DIGEST

Carl Gosline, *B.S., Iowa '41, conducts meteorological engineering studies to help solve plant chimney problems involving smoke and acids.*

Engineering Unlimited

Training in many different engineering branches opens the door to opportunity at Du Pont

In recent issues of the *Digest*, we have discussed opportunities for mechanical and chemical engineers at Du Pont. However, this is only part of the picture. The special skills of more than a dozen different branches of engineering are needed on our scientific teams. For example:

Architectural, civil and structural engineers are attached to the central Engineering Department which handles most of the Company's construction projects. In this work they make site investigations, lay out new plants, design buildings, determine construction methods and specify materials and equipment. They also assemble necessary labor forces at field locations and supervise the building and assembly of complex manufacturing facilities.

Electrical engineers aid in designing process equipment and facilities for power generation and distribution, air conditioning and refrigeration. Instrumentation is another important phase of their work. Continuous automatic analyzers for cyanides, ultra-violet gas analyzers, multivariable recorders, and new photo-multiplier circuits are just a few of their developments.

Industrial engineers help develop methods and standards for new or improved manufacturing processes. This work often serves as training for production supervisors.

Metallurgical engineers play an essential part in the central Engineering Department's program of research. Their studies are aimed at improving equipment and construction materials, as well as methods of measurement and control.

Safety engineers strive constantly to improve the broad safety program initiated by the Company's founder 150 years ago. Du Pont is understandably proud of its safety record, which in 1950 was eight times better than the chemical industry's as a whole, and fourteen times better than the average for all industry.

This by no means completes the list. Every U. S. industry utilizes Du Pont products. Hence there is also a need for specialists in mining, petroleum, textiles and many other branches of engineering.

Along with chemists, physicists and other technical personnel, almost every kind of engineer finds opportunity at Du Pont. Your engineering degree is only a door opener. Any man with ideas, imagination and the ability to handle people will find plenty of room for advancement in this company that has never stopped growing.

FOR HELP in choosing your career, send for free copy of "The Du Pont Company and the College Graduate." Describes futures for men and women with many types of training. Address: 2521 Nemours Bldg., Wilmington, Delaware.

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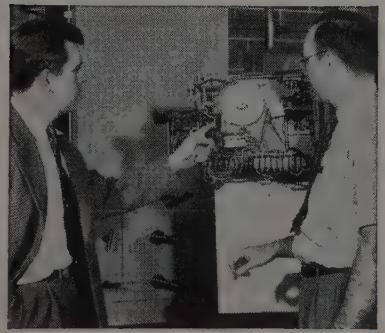


Fred R. Struder, *B.Metal.E., Rensselaer P. I. '50, examines a pressure strain recorder with Allen R. Furbeck, E.E., Princeton '39.*

This Du Pont plant, *near Orange, Texas, manufactures nylon intermediates, plastics and heavy chemicals. Engineers attached to The Du Pont Company's central Engineering Department designed the plant and supervised the installation of the manufacturing equipment.*

INTRODUCING . . .

(*continued from page* 18)

engineering department's network analyzer.

Dr. Ryder was born in Columbus, Ohio, in 1907. He received his Bachelor's Degree in 1828 and again later, his Master's Degree from Ohio State university. Upon receiving his Master's he was employed by the General Electric company, where he specialized in electronic work and the development of thyrotrons under H. C. Steiner.

In 1931 Dr. Ryder joined the Bailey Meter company of Cleveland, as supervisor of the electronic section of the research laboratory. He holds 24 patents in this work, which consisted of temperature-recording and automatic control applications of electronics. The Bailey "Pyratron" group of devices and the General Electric and Weston photoelectric and potentiometer are now being manufactured under these patents.

Dr. Ryder furthered his graduate education by studying mathematics and atomic physics at the Case School of Applied Science while he was still at Bailey Meter.

In 1941, Dr. Ryder gained an assistant professorship of electrical engineering at Iowa State college. In 1944 he became professor of electrical engineering in charge of electronics courses and in the same year was awarded his Ph.D. degree in electrical engineering by the Iowa State college. From September 1944 to April 1946 he was temporarily professor in charge of the electrical engineering department.

DR. JOHN D. RYDER

In 1947 he became assistant director of the Iowa Engineering Experiment Station and continued in that capacity until the fall of 1949, when he was appointed head of the University of Illinois electrical department, the position vacated by Dean W. L. Everitt when he became dean of the college of engineering.

Dr. Ryder has written two textbooks, *Electronic Engineering Principles* (Prentice-Hall, Inc.) and *Networks, Lines and Fields* (Prentice-Hall, Inc.); these texts are currently being used in the courses EE 340 and EE 351, respectively. He has also authored various other authoritative papers on A.C. and D.C. motors, vacuum tube voltmeters, electronics and more recently, network analyzers.

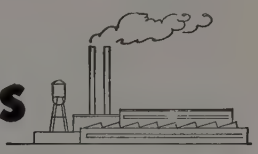
An avid radio "ham," he operates his own station, W9UDE. Another interesting hobby which he has is color photography and he owns over 2,000 of his own Kodachrome photographs of western national parks. He also enjoys playing tennis when he can find the time.

Dr. Ryder is a member of many associations and organizations. He is a member of the American Association for the Advancement of Science, Director of the Institute of Radio Engineers and chairman of the committee of education for the same organization, and chairman of the electronics education subcommittee all of the American Institute of Electrical Engineers. Some of the honorary fraternities to which he belongs are Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

The work which Dr. Ryder and his department have set before themselves for the following year is that of the design and construction of an analog computor, which will solve differential equations. The network analyzer has been completed and its formal dedication has been scheduled for the 30th of April.

It can be seen from his educational background and practical experience that Dr. Ryder is exceptionally qualified for the work he is doing here. The combination of this educational experience and interest in activities exemplifies Dr. Ryder as one of the more distinguished personalities and educators on this campus.

for all industries



Agricultural Equipment
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The most complete line of ball bearings and power transmission units in America. The Fafnir Bearing Company, New Britain, Conn.

Facts about Fafnir

Fafnir's four New Britain plants contain nearly 19 acres of floor space.

"When I took the 'STADIUM ROUTE' bus to Urbana yesterday, Stalin sat next to me."

"You're crazy! The 'STADIUM' bus doesn't go to Urbana."

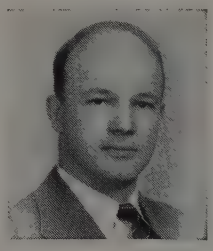
* * *

Canibal No. 1: "Am I late for chow?"

Canibal No. 2: "Yes, everybody's eaten."

"Find Yourself"
...without losing time!

by FLOYD O. SMELTZ, *Supervisor, Standardization Section*
WEST ALLIS WORKS (*Graduate Training Course 1950*) *Ohio State—EE—1949*



FLOYD O. SMELTZ

SELECTING a specific job in the engineering field after graduation from college is a tough proposition for most of us. It was for me, and that's why I came to Allis-Chalmers. I thought I wanted to be a development engineer but I wasn't sure. Allis-Chalmers Graduate Training Course gave me an opportunity of trying design and development—and other types of work also. By my own choosing I am now engaged in challenging work which I hadn't even considered while in school. The point is, all GTC's have the same chance of "finding themselves."

Allis-Chalmers car shaker empties coal and ore cars in minutes. Saves time . . . prevents injuries by keeping men out of car interiors.

That's the outstanding feature of Allis-Chalmers Graduate Training Course. You have a very broad selection, and you yourself choose the type of training you receive. Of course you get help and guidance from experienced men throughout your training period. You need it, since there are jobs here that you have never dreamed of.

Finds Job Challenging

Take my job for instance. To the engineering student it probably sounds rather dull when compared with Advanced Thermodynamics or Electric Transients in Power Systems. But, in my opinion, the most fascinating science is coordinating engineering and production efforts through standardization of procedures, parts and materials. As Supervisor of the Standardization Section and Chairman of the Standards Committee, I encounter new problems every day—no monotony here.

But that is only part of the story! I am also Secretary of the Chief Engineers' Committee and Secretary of the Development and New Products Committee. What could be more stimulating for a young engineer than to be at the crossroads, where he can watch the engineering planning of an expanding company?

No Limit to Opportunities

I never thought I'd be doing this when I graduated from Ohio State in 1949 and enrolled in Allis-Chalmers Graduate Training Course. As I mentioned, I was particularly interested in design work at that time. In fact, right now there is a patent applied for on an electro-magnetic relay device I designed. Yes, they even let me do development work while still a GTC student.

A student helps plan his own courses and is free to change his plans as new interests, new opportunities present themselves. He can divide his time between shops and offices—switch to design, manufacturing, research, application engineering, sales, or advertising—and can earn advanced degrees in engineering at the same time.

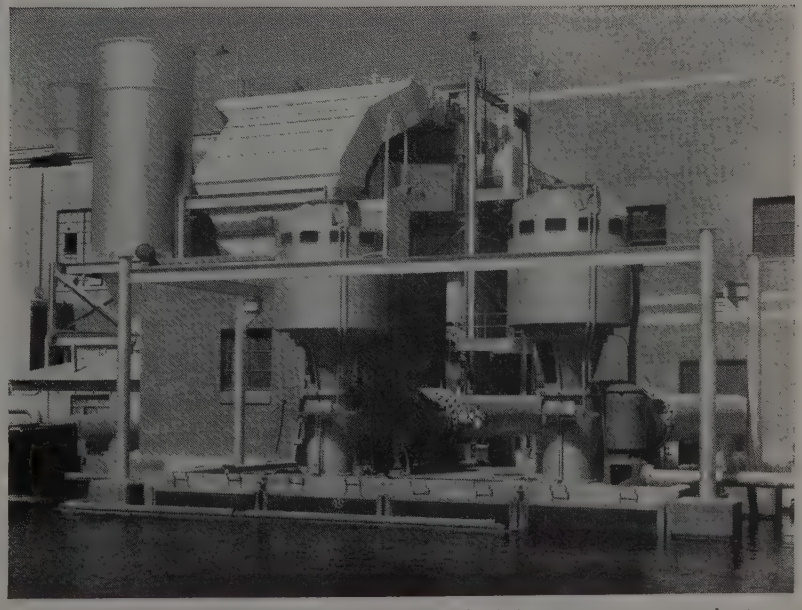
When he graduates from the course he is encouraged to go into the type of work he liked best while on the Graduate Training Course.

One of the reasons Allis-Chalmers offers so many opportunities is that A-C designs and builds machines for every basic industry, such as: steam and hydraulic turbine generators, transformers, pumps, motors, rotary kilns, crushers, grinders, coolers, screens, and other machinery for mining, ore processing, cement, and rock processing. Then there are flour milling, electronic equipment and many others.

There is no other organization that seems to me to offer the graduate engineer such a wide range of activities, or that gives him such a chance to find the type of work for which he is best fitted.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin



Weatherproof motors for condenser cooling water circulating pumps were mounted outdoors to conserve valuable building space for a Texas utility.

The Magic Slide Rule

by Lee Grossman, m.e. '53

Not too long ago when all the world was plunged into the scientific approach, just after Copernicus was hanged by his heels because he declared his belief that the sun was the center of the solar system, and proved it by that method which we accept and even glorify, there lived a little man in the town of Sorento where all the little glass figures of women come from.

This little man was not interested in little glass figures. Rather, he had an all consuming interest in an invention which he called his slideth stick. It was a queer gadget and people came from all around to see it operate. When they saw it they laughed and cried, "Torcelloni has gone mad. See how he moves that stick. Who would spend all his time with a little wooden stick when he could be making little glass figures like his father."

Torcelloni would remain calm at these outbursts. He would just smile and slide his slideth stick back and forth, reading figures all the time. If anyone would be interested enough to ask a question, Torcelloni would sit them down and talk for hours about the wonders of his slideth stick. Then they would nod their head "yes" and walk away scratching their heads.

This went on for several months. People would come to see the crazy man of Sorento slide pieces of wood between his fingers. "That's not the way to make fire they laughed." One fellow even tried to burn his wooden stick and Torcelloni along with it. Torcelloni remained unmoved.

Now it so happened that at the University of Florence there lived a professor who was known for his theories on mathematics. Torcelloni decided to take his slideth stick to this man and let him decide its worth. Torcelloni got on his mule and rode for two days and two nights until he finally arrived at the gates of Florence. Then he saw the professor and showed him the stick with which he could do mathematical problems that would take the ordinary mathematician hours to do. The professor, a very learned man, was amazed at the slideth stick. He had never in his life seen the equal of this stick. Here was a stick that was truly magic.

The professor praised Torcelloni for his genius and asked him all sorts of questions about the slideth stick. They talked for hours and finally the professor said, "Come, my friend. You must be hungry. Let us eat." They put the slide rule down near the fire while they went to supper.

The fire was blazing because it was cold outside. All the good housekeepers of Florence keep a blazing fire going when it is cold outside. One of the sparks from the fire happened to strike the cushions of the chair where Torcelloni placed his slide rule. In less time than it takes to tell, the chair and the slide rule were burned to a crisp, and the room itself was all in flames. The professor and Torcelloni jumped up and rushed to the fire house in the town square. All the townspeople came to help put out the fire for they dearly loved the professor for he was known for his acts of kindness.

Soon the fire was put out and the damage surveyed. The house wasn't badly burned, but all that remained of the cushioned chair and the slideth stick was a pile of ashes and a bit of horse hair. Torcelloni began to weep for the loss of his slideth stick. The Professor, who loved his cushioned chair felt very badly too, but he consoled his friend. "Now now. We can build another one even better than the first one." But Torcelloni couldn't be consoled. The very next day he set out for Sorento.

The kindly professor, whom everybody loved, never tried to duplicate the slideth stick, although many times he was tempted to try. As for Torcelloni, he too forgot his slideth stick and turned to making little glass figures. Perhaps this was best, for Torcelloni couldn't duplicate his slideth stick even if he tried. In those days, before the era of scientific approach, the people believed in magic. Torcelloni too believed in magic, and he believed that Torres, god of reasoning, had charmed his slideth stick. Now it could never be charmed again, for Torcelloni no longer believed in magic. His slideth stick taught him to believe in science.

Should Torcelloni have been less the scientist and more the fool, the world today might have benefitted, for this magic slideth stick was nothing more than our everyday slide rule with one exception: Torcelloni's slideth stick placed the decimal point.

SKIMMING . . .

(*continued from page* 42)

the research laboratories of the American Petroleum Institute, a service organization for the entire industry. In addition, many graduate and undergraduate chemical and chemical engineering labs are involved in delicate measuring projects. Westinghouse Sturtevant fans. air-conditioning, and heating units play an indispensable role in the maintenance of required atmospheric conditions and removal of undesirable fumes in the labs.

In one section, the purity of a hydrocarbon is checked by measuring its freezing point. By use of the platinum resistance thermometer and an extremely accurate resistance bridge, they will be able to obtain an accuracy within 0.002°C in freezing point comparisons. Of course, it is imperative that the atmospheric conditions here remain constant, and in the required state. Here, as well as in other sections where temperature measurements as accurate as 0.001°C are made, precise control must be maintained.

unique dry-process copying technique

A new, rapid, and exclusive dry-process method for making exact and permanent copies of all types of written or printed material has been announced by Minnesota Mining Co. Called "Thermo-Fax," the "method" employs a new duplicating machine and heat-sensitive paper.

An infra-red light is sent through the heat-sensitive sheet to the original. The rays, striking the black type face, are converted into heat which reproduces the original on the sheet.

This new process requires no negatives, chemicals, washing, or drying. The permanent copies, produced in 15 seconds, ready to distribute, do not fade or change color.

The sheets used in this process are not sensitive to light and may be stored in any convenient area. No proof reading is necessary and copies of secret documents may be made by officials without assistance.

Back in 1921, an engineer's definition of a slide rule went like this:

"A slide rule is something like a woman. It is slippery and no one ever learns to manage one. It has a variety of figures which are more or less true. Men are crazy until they get one and after they get it, they wish that they had saved their money. But, unlike a woman, a slide rule can be put in a leather case and shut up."

"We talked JOBS over the coffee"

Listen to an alumnus talking – and consider his remarks:

"The other night, I went to my college class dinner–the annual get-together of Tech Class of '41. After dinner, we sat around over the coffee –talking about all the things the last eleven years brought us. You know–a typical bull session.

"Pete Berry was sitting next to me. He was voted 'most likely to succeed' back in '41. But he's been going from job to job ever since the war. Looking back now, it's easy to see why.

"Like others in our class, he went into defense work that June. Did a good job, too – and so did his company. But unfortunately his company was a 'war baby' and a couple of months after the Japanese surrender –poof, no company and no job. He's been moving around ever since.

"But I played it safe. I picked Goodyear Aircraft Corporation to work for – and I've been there ever since. They're a subsidiary of the world's largest rubber manufacturing company, so I knew that GAC would still be around–still be doing business come defense, war or peace. I knew they were even then doing plenty besides turning out aircraft and parts–because GAC is an *engineering* organization and a *production* unit.

"You know, as we sat there over our coffee, Pete said something that made a lot of sense. He told me 'If I were picking my first job today, I'd play it the way you did–pick a company that's going to be in business for keeps.'

"That's pretty good advice for anyone looking for an engineering spot today–pick a company like Goodyear Aircraft, and hold for the long pull."

Think, man! That could be you talking ten years from now.

Whatever engineering field you're trained for, you'll find current projects under way to interest you at Goodyear Aircraft.

And you'll find activities ranging far from the aeronautical operations implied by the name of the company. More important–you can be sure that GAC will carry on – come what may–as a subsidiary of Goodyear, The Greatest Name in Rubber.

Make a note right now to investigate job opportunities with Goodyear Aircraft Corporation. See how much GAC has to offer YOU.

GOODYEAR AIRCRAFT

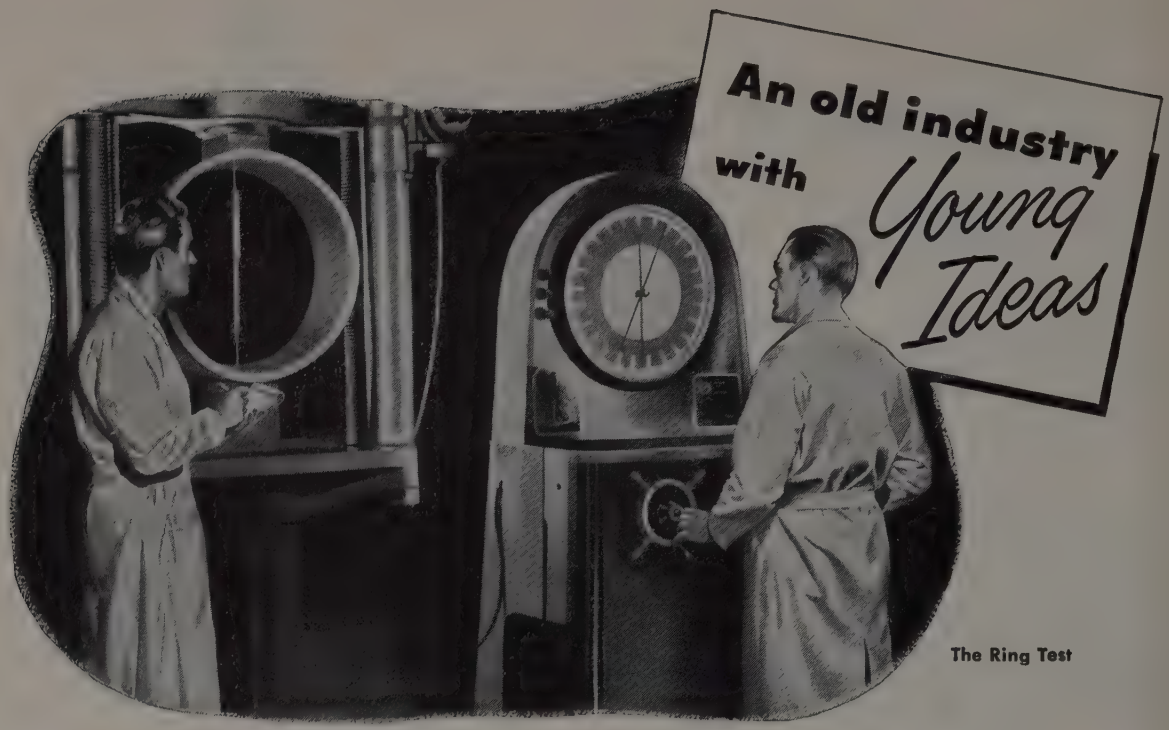
ENGINEERS—INVESTIGATE THESE OPPORTUNITIES!

In research, design and development of:

AIRPLANES, AIRSHIPS, HELICOPTERS, GUIDED MISSILES, ELECTRONIC COMPUTERS, AIRCRAFT COMPONENTS, GUIDANCE SYSTEMS, TRANSPARENT ENCLOSURES, REINFORCED PLASTICS, RADOMES, BONDED SANDWICH STRUCTURES, WHEELS AND BRAKES, RADAR STRUCTURES and many others.

Submit brief resumé of your qualifications and experience for prompt consideration to: Salary Personnel Department, Goodyear Aircraft Corporation, Akron 15, Ohio.

GOODYEAR—The Company With COMPLETE Coverage of the Aeronautical Field



The Ring Test

The ring test, shown above, is a scientific method for determining the modulus of rupture of pipe. It is not a required acceptance test but one of the additional tests made by cast iron pipe manufacturers to ensure that the quality of the pipe meets or exceeds standard specifications.

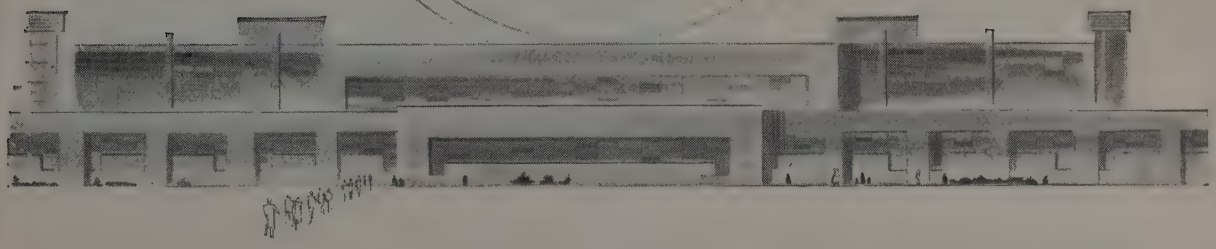
A ring, cut from random pipe, is subjected to progressively increased crushing load until failure occurs. Standard 6-inch cast iron pipe, for example, withstands a crushing weight of more than 14,000 lbs. *per foot.* Such pipe meets severe service requirements with an ample margin of safety.

Scientific progress in the laboratories of our members has resulted in higher attainable standards of quality in the production processes. By metallurgical controls and tests of materials, cast iron pipe is produced today with precise knowledge of the physical characteristics of the iron before it is poured into the mold. Constant control of cupola operation is maintained by metal analysis. Rigid tests of the finished product, both acceptance tests and routine tests, complete the quality control cycle. But with all the remarkable improvements in cast iron pipe production, we do not forget the achievements of the early pipe founders as evidenced by the photograph below of cast iron pipe installed in 1664 to supply the town and fountains of Versailles, France and still in service. Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction. Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3, Illinois.

Section of 285-year-old cast iron water main still serving the town and fountains of Versailles, France.

CAST IRON PIPE SERVES FOR CENTURIES

NEW research expansion AT DOW



Research is the cornerstone of rapid growth in the chemical industry. The continuance of this growth at Dow is assured by expanded research facilities requiring the talents of many scientific people in widely varying fields of endeavor.

At the home plant in Midland, Michigan, Dow is building another completely new laboratory to augment the current work in organic chemistry. Increased facilities for Dow's progressive work in spectrographic analysis is planned to keep pace with important advances in this field.

In Dow's Freeport, Texas Division, even greater research expansion is taking place. Here a huge research center consisting of eight buildings is under construction. This center, which will include a modern technical library, will have a total floor space of 57,000 square feet.

Dow's booklet, "Opportunities with The Dow Chemical Company," especially written for those about to enter the chemical profession, is available free, upon request. Write to The Dow Chemical Company, Technical Employment, Midland, Michigan.

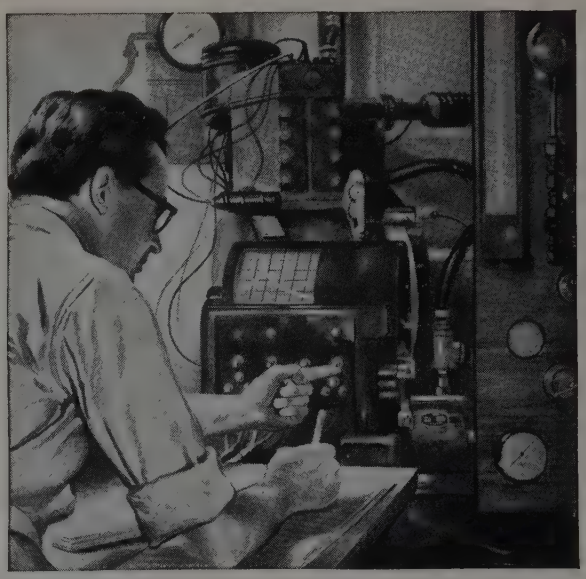
THE DOW CHEMICAL COMPANY

Midland, Michigan

DOW
CHEMICALS
INDISPENSABLE TO INDUSTRY AND AGRICULTURE

Opportunities at General Motors:

The difference between a GM job and any other—for you, the Graduate Engineer



FROM the start, General Motors offers the engineering graduate both the opportunities and facilities of a large, successful organization, and the friendly working environment of a smaller company.

GM is not only a major producer of motorcars and trucks; it also is a leading manufacturer of many types of civilian goods, from heating systems to refrigerators, from fractional h.p. motors to Diesel locomotives.

And as a top defense contractor, GM is building everything from rockets and shells to tanks and jet and Turbo-Prop engines.

In these operations we require the services of all types of engineers, engaged in all phases of engineering work—from pure research to production supervision.

This work is decentralized among GM's 34 manufacturing divisions, operating 112 plants in 54 towns and cities throughout the country. Each division operates as an independent unit with its own engineering department. Yet each benefits from the resources of GM's central research and engineering laboratories.

That, then, is the difference between a GM job and any other.

Today many GM divisional managers are engineering school graduates. So are many others in top management. In fact, a high percentage of the engineering graduates who have joined General Motors have made sound business careers for themselves at GM, through their own hard work and initiative.

For further information on a GM engineering career, we suggest you ask your College Placement Office to arrange an interview for you with the GM College Representative the next time he visits your campus.

GM POSITIONS NOW OPEN IN THE FOLLOWING FIELDS:

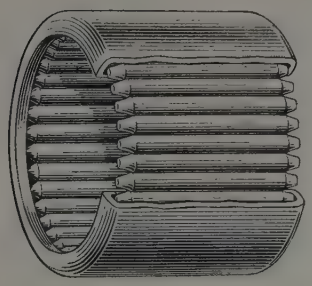
Mechanical Engineering • Electrical Engineering
Metallurgical Engineering • Industrial Engineering
Chemical Engineering • Transportation Engineering

See December 1951 issue of Fortune Magazine for description of new multimillion dollar GM Research and Technical Center in Detroit.

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

The Torrington Needle Bearing needs little space—saves time in assembly



The Torrington Needle Bearing is a completely self-contained unit consisting of a full complement of small diameter rollers and a single retaining shell. This unit design and construction greatly simplify handling and speed assembly, and help reduce the size and weight of related parts.

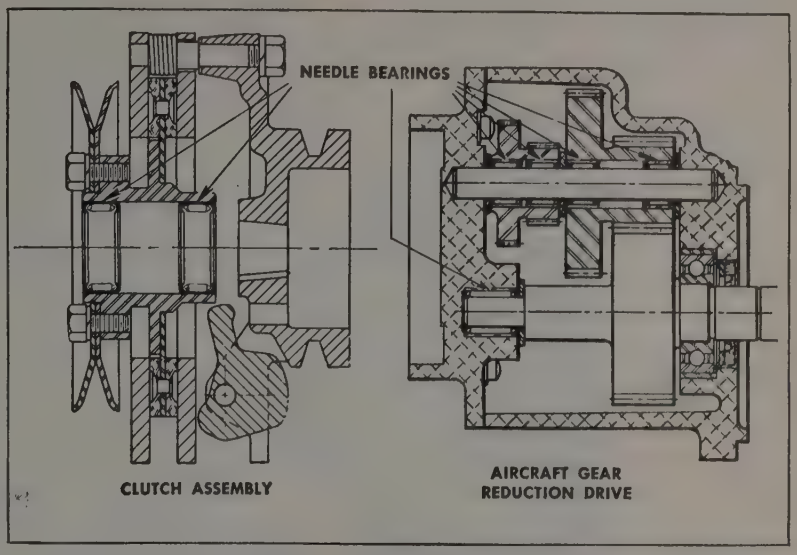
High Load Capacity in Small Space

Because the many rollers distribute loads over a large contact surface, a Needle Bearing has a very high load capacity in relation to its size. In fact, the Torrington Needle Bearing has a higher rated radial load capacity than any other type of anti-friction bearing of comparable outside diameter. This not only permits the use of a smaller, lighter bearing for a given load, but also allows reductions in the size and weight of housings and other related components. The Needle Bearing's large inside diameter permits larger shafts to be used in cramped quarters, an important factor in many designs.

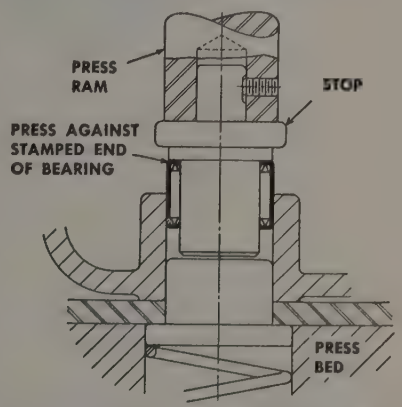
Installation Simplified

The installation of Torrington Needle Bearings is fast and easy. The housing bore is simply machined to proper diameter. The bearing is then pressed into this housing. An arbor press is normally used for this operation. No spacers or retainers are needed to keep the bearing in place. An accurately made shaft is required, of course, as it serves as the inner race in most cases and must be hardened and ground to correct size. For applications where an unhardened shaft is desired or necessary, inner races can be furnished for all Needle Bearings.

These advantages make Torrington Needle Bearings ideal for applications where space or weight is at a premium, or where mass production methods necessitate the use of a bearing that is as easy as possible to handle and install.



Typical installations of Torrington Needle Bearings are characterized by simplicity of design. Needle Bearings are made for shafts as small as 5/32" up to those as large as 7¼".



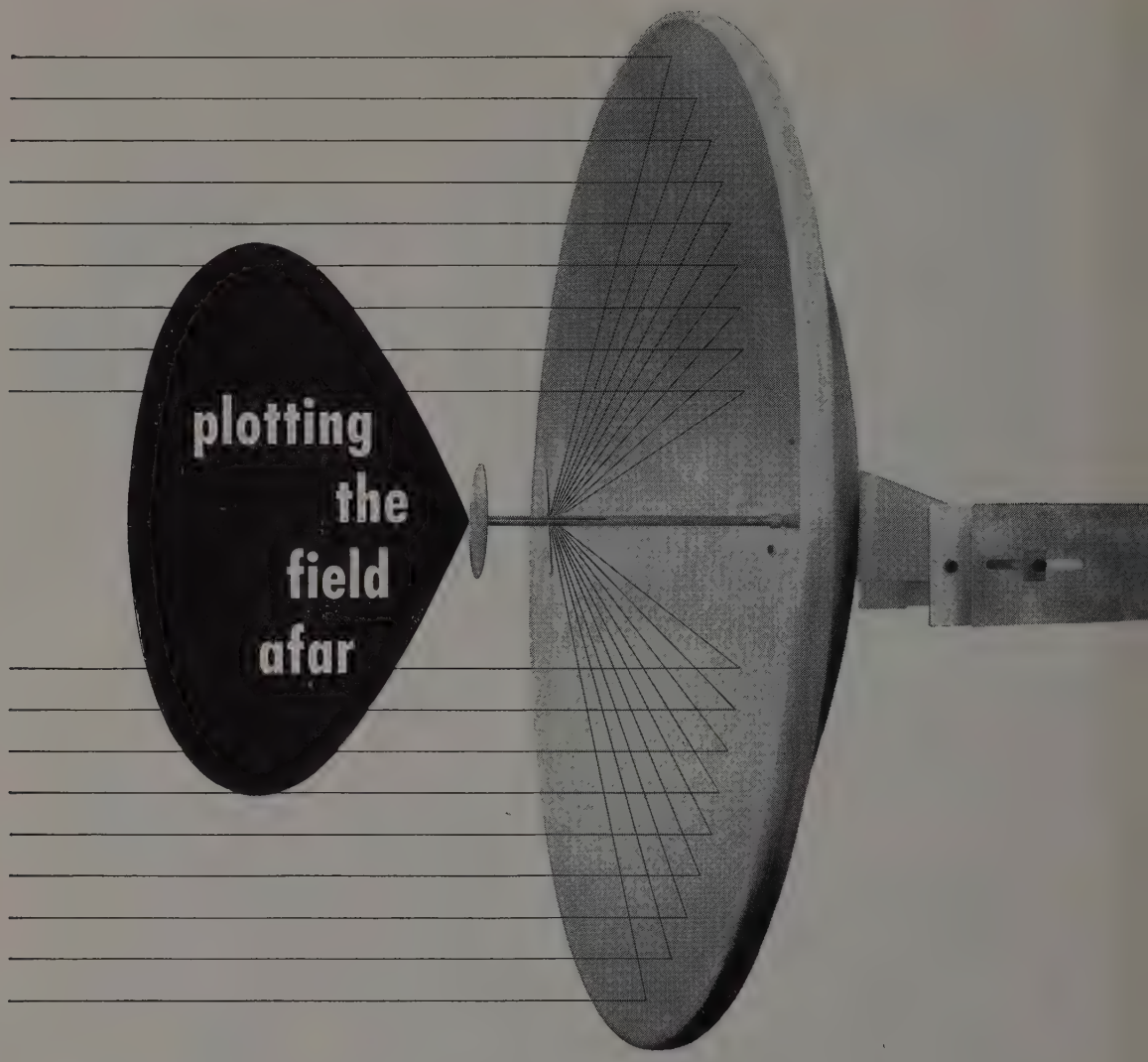
The use of proper tools for installing Needle Bearings speeds up assembly. The arbor press tools above are ideal.

Other features of Torrington Needle Bearings will be covered in other advertisements in this series. For additional information regarding Needle Bearings, please contact our engineering department.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS



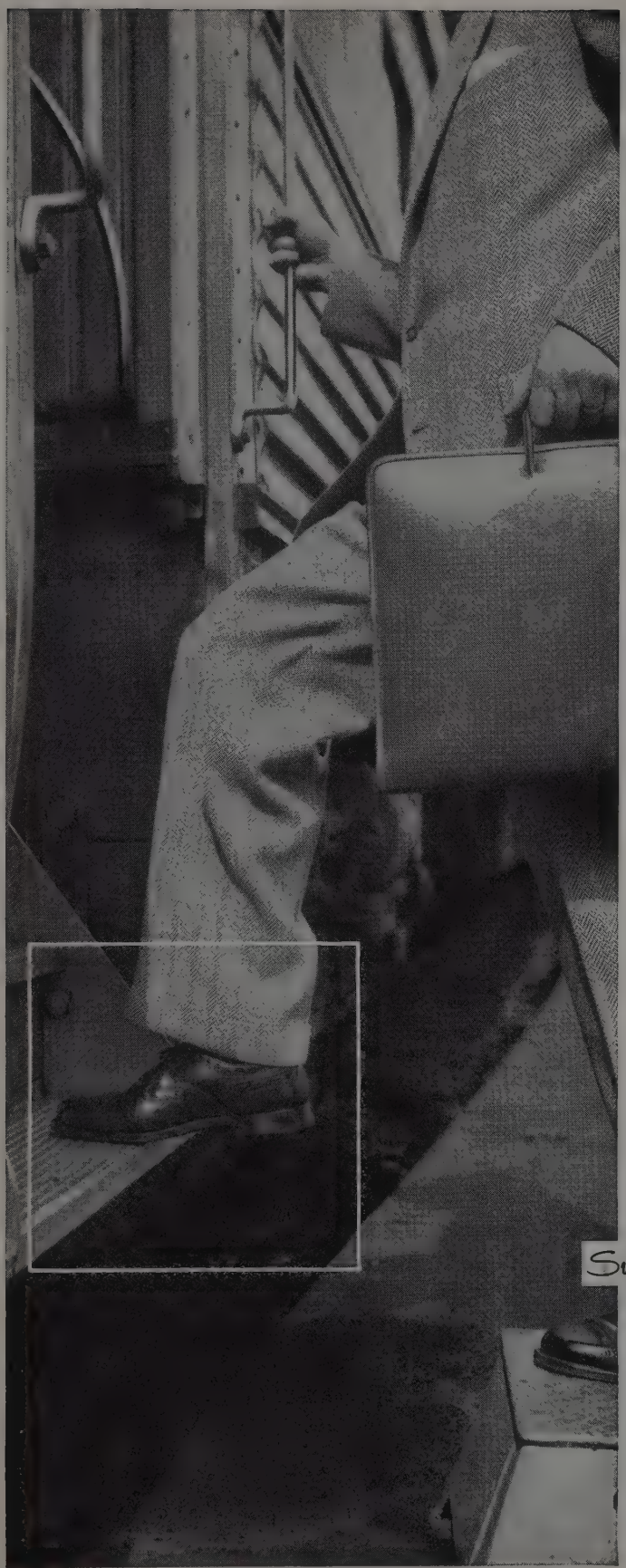
Plotting the radiation pattern of a microwave antenna is typically time consuming and laborious. For some time, workers in this field have felt a need for a continuous non-manual means of performing this operation. The extensive microwave activities of its Research and Development Laboratories have created at Hughes a special interest in such automatic pattern-measuring equipment.

The first automatic machines that were at all accurate were of the fixed location type and weighed nearly a ton. The new Hughes recorder weighs just one hundred pounds, is more accurate, and has higher writing speeds than the earlier machines. Its recording range covers 80 decibels in the audiofrequency spectrum. The writing speed is approximately 25 inches per second, with an 8"x11" plot, and the abscissa or angle scale is controlled by an electrical take-off system.

In the field of microwave measurements, this machine assists in determining many things — such as the correct shape of reflectors and the proper location of feeds. The development of such improved laboratory tools is an interesting by-product of a large research activity, such as that conducted by the 3500 men and women of the Hughes Research and Development Laboratories.

The growing requirements of both the commercial and military electronics programs at Hughes are creating new positions within the Research and Development Laboratories. Graduate students and senior men are cordially invited to address correspondence to:

Hughes Research and Development Laboratories
Engineering Personn
Department
Culver City, Los Ang
County, California



APPOINTMENT WITH TIME

When you travel by train (or, for that matter, by plane or any public carrier) you expect to arrive on time. Unconcerned, you click-click across switches in the yard district . . . swish past the clang of grade crossings . . . roar by freights only a few inches away . . . Your confidence lies in experienced railroaders and properly maintained roadbeds and signal equipment.

Over every mile of track, your safe and speedy progress is guarded. Guarded by semaphores, position and color light signals, dwarf signals, automatic train controls, interlocking control machines in far-away towers, and other elements in an all-inclusive safety pattern.

An *unseen essential* in this safety pattern, reliable and hard-working, is *Synthane*. Synthane is a strong, light-weight, laminated plastic. It's an excellent electrical insulator, moisture and chemical-resistant, hard, tough and dense. It is also easy to machine. Synthane is a material for small parts or large on any job where a combination of properties is needed and good performance is a "must".

Maybe you can use Synthane profitably. To find out, send for the complete Synthane catalog. We will be glad to help you with design, sheets, rods, tubes or fabricated parts. Synthane Corporation, 10 River Road, Oaks, Pennsylvania.

Terminal Board (left) for continuous train control and relay pusher (right). Both pieces are made from Synthane laminated plastics for General Railway Signal Co., Rochester, N. Y.

Synthane-one of industry's unseen essentials

SYNTHANE

LAMINATED PLASTICS

I am Industry—1952

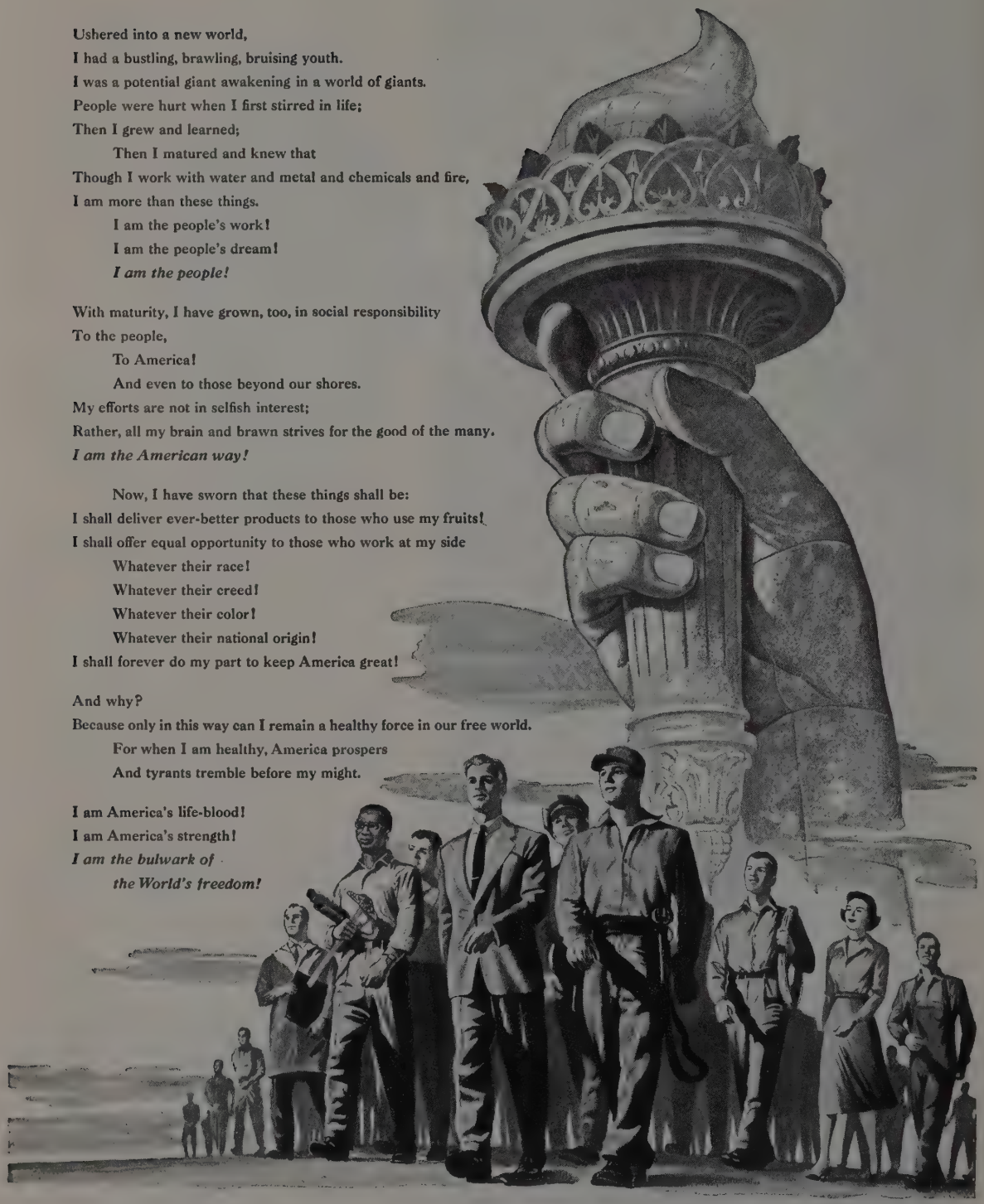
Ushered into a new world,
I had a bustling, brawling, bruising youth.
I was a potential giant awakening in a world of giants.
People were hurt when I first stirred in life;
Then I grew and learned;
Then I matured and knew that
Though I work with water and metal and chemicals and fire,
I am more than these things.
I am the people's work!
I am the people's dream!
I am the people!

With maturity, I have grown, too, in social responsibility
To the people,
To America!
And even to those beyond our shores.
My efforts are not in selfish interest;
Rather, all my brain and brawn strives for the good of the many.
I am the American way!

Now, I have sworn that these things shall be:
I shall deliver ever-better products to those who use my fruits!
I shall offer equal opportunity to those who work at my side
Whatever their race!
Whatever their creed!
Whatever their color!
Whatever their national origin!
I shall forever do my part to keep America great!

And why?
Because only in this way can I remain a healthy force in our free world.
For when I am healthy, America prospers
And tyrants tremble before my might.

I am America's life-blood!
I am America's strength!
I am the bulwark of
the World's freedom!



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AT JOINT Technical Meetings of Standard Oil Company and its subsidiaries, many opportunities are presented for an easy exchange of ideas. From formal meetings, where technical papers are read, to small discussion groups and conversations between individuals, a healthy and stimulating air prevails throughout the five-day meeting.

How Exchanging Ideas Advances Petroleum Progress

WHEN MORE than 150 scientists meet for five days and exchange views on their work during the past year, the American consumer is likely to benefit, through improvement of products for his use. Conversation between scientists can often accomplish a more complete and satisfactory coordination than mere exchange of written reports.

From May 5 through May 9 this year, the Standard Oil Company (Indiana) and affiliated companies held their tenth annual Joint Technical Meeting at French Lick, Indiana. The key scientists and engineers from the parent company and all its subsidiaries attended. More than eighty technical papers were presented.

In addition to the research men, the manufacturing, production, sales, chemical products, and patent departments of the companies were represented. This helped give a broad view of company problems.

The Standard Oil Joint Technical Meetings are outstanding in their field. The company has been a pioneer in bringing together scientists and engineers from all the branches of its activities.

This is another example of leadership in engineering and research, and well illustrates the progressive atmosphere men with technical training may find in a career at Standard Oil.

Standard Oil Company

910 South Michigan Avenue, Chicago 80, Illinois

STANDARD

Takes a lot to lay a carpet in the jungle

The scene is "darkest Africa".

But Africa is lightening. Man's quest for minerals, for new areas for agriculture and trade, is slashing ultra-modern, glaring-white air strips in once impenetrable jungle.

Those pavers, portable air compressors, pumps and air tools—such as you might see working a city street—are Worthington Blue Brutes going to "lay a carpet" in that hole in the jungle.

Thus, Worthington, a major producer of equipment for public works, industry and farm, brings the fruits of American technical genius to the strange places of the world.

And illustrates, too, how the unique American talent of *diversification* helps public, employees and stockholders. For Worthington makes many things—not just construction equipment and pumps, but also engines, water works machinery, power transmission, petroleum equipment, air conditioning and refrigeration, many others.

Such diversification builds *stability* . . . makes Worthington, 112 years old, a strong link in the chain of American business.

Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Harrison, New Jersey.

WORTHINGTON

The Sign of Value Around the World

1.14

Good Water and Sanitation—engines pumps • water treatment • comminutors air compressors • air tools

Lower-Cost Manufacturing—pumps compressors • steam turbines • motors power transmission • air conditioning

Petroleum Products—compressors engines • pumps • chilling equipment refrigeration • decoking systems

More Abundant Food—compressors fertilizer mixers • air conditioning refrigeration • pumps

All kinds of engineering jobs call for photography

Let's say you're going to engineer tomorrow's global transportation systems—explore inaccessible areas for new mineral deposits—or that you'll design a new machine or product. All along the engineering way, you'll find photography playing an important part.

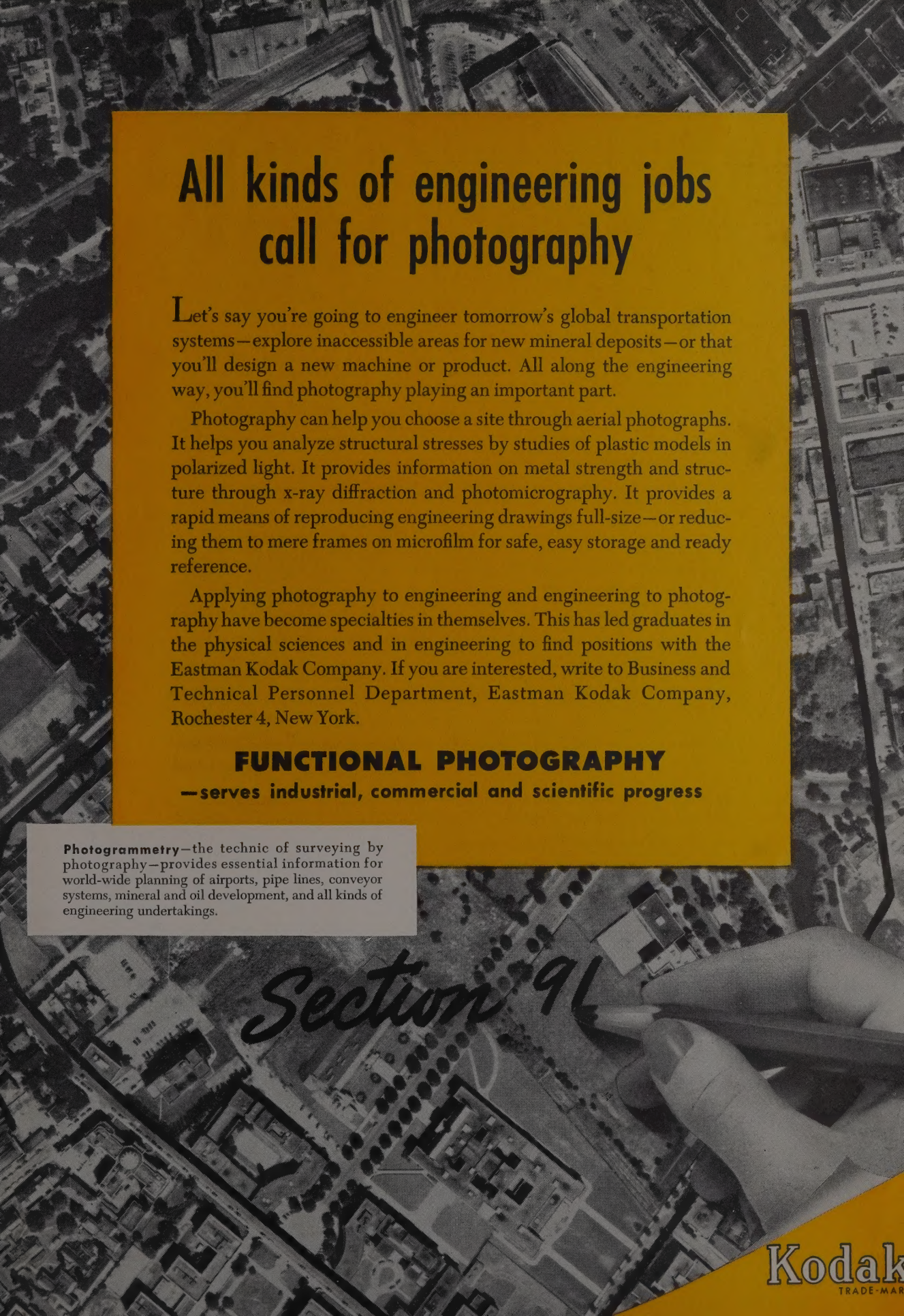
Photography can help you choose a site through aerial photographs. It helps you analyze structural stresses by studies of plastic models in polarized light. It provides information on metal strength and structure through x-ray diffraction and photomicrography. It provides a rapid means of reproducing engineering drawings full-size—or reducing them to mere frames on microfilm for safe, easy storage and ready reference.

Applying photography to engineering and engineering to photography have become specialties in themselves. This has led graduates in the physical sciences and in engineering to find positions with the Eastman Kodak Company. If you are interested, write to Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, New York.

FUNCTIONAL PHOTOGRAPHY

—serves industrial, commercial and scientific progress

Photogrammetry—the technic of surveying by photography—provides essential information for world-wide planning of airports, pipe lines, conveyor systems, mineral and oil development, and all kinds of engineering undertakings.



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JUN 1 ° 10

WE ASKED GRADUATES TEN YEAR[S] OF COLLEGE:

WHAT WOULD YOU SUGGEST [TO] NOW PLANNING THEIR CAREERS?

This advertisement is another in a series written by G-E employees who graduated ten years ago—long enough to have gained perspective, but not too long to have forgotten the details of their coming with the Company. These graduates were sent a questionnaire which they returned unsigned. The quotes below represent only a sample of the suggestions received. For a free, mimeographed copy of the full list of comments, write to Dept. 221C-6, Schenectady, N. Y.

"The advice should go back to the sophomore level and it would be to take as many fundamental engineering courses as possible instead of specializing in one field during junior and senior years. The specialization will come as a matter of course due to participation in a phase of engineering occupation after graduation."

"Obtain working experience in all the jobs you think you know nothing about and avoid your primary interest the first year out of college. Ignore geographic location when selecting a job. Even Schenectady is an enjoyable place to live when you've been there long enough to know how to appreciate it. Respect and admire your boss or change bosses."

"Too many of today's graduates are hypnotized by the glamor fields of rockets, jets, etc., whereas they are overlooking good opportunities in the old standard lines."

"Come with G.E., take advantage of opportunity to find field of most interest and possible reward. Don't jump to any foregone conclusions, and don't hurry to find a 'permanent' job."

"This is for freshmen . . . Go to a school that will give you an excellent background in fundamentals of physics, math, mechanics, and materials. Spend at least 25 to 30% of your time in the study of humanities. Forget about machine shop and drawing courses and practical application. Get your practical experience eventually from a company. In a few years you will be worth 10 times more to them and yourself than the so-called practical student."

"Be thoroughly grounded in engineering fundamentals. Experiment in your likes and dislikes by trying several jobs. Work for a company that helps you do this."

"I think the General Electric Test Engineering Program is the ideal employment for the graduate engineer. He should spend the full time on Test with many assignments to obtain the background that will be of utmost value to him."

"Don't specialize too much. Get your fill of math, physics, and so-called liberal arts."

"Don't be afraid to change either training or vocation if you find you don't like it."

"Get a line of work in which you are sincerely interested; it should be a pleasure to get up and go to work in the morning."

"It is a rare thing, one to be cherished as a golden opportunity, to be able to move around on rotation, look over the best facilities and opportunities of a company and thereby be able to make a much more considered choice of where, finally, to work. These things are all possible on the G-E Test Course."

"The most pleasant life seems to be in the sales end of the business. This is what I would tell the college men to strive for if he is fitted for sales work."

"If you don't find your work interesting after five years or rewarded with responsibility and money after 10 years—quit."

"I have worked with hundreds of young fellows since I was on the Test program. Only a few of them knew exactly what they wanted a year or even two years after graduation. One advantage of working with a large company is that it gives them an opportunity to observe a broad field of activities—everything from betatrons to garbage disposers—locomotives to guided missiles. The most important thing in selecting a job is choosing one that will keep the individuals happy, contented and satisfied."

"Get with the company that offers the best training program—the longer the better."

"G-E Test is the best way to spend first 2 years after school—particularly if the graduate is undecided as to his field."

You can put your confidence in—

GENERAL ELECTRIC

407-32C